REV.	DESCRIPTION	ECN	DATE

CR-171 926

A	Original Issue		Jan 84
B	Changes for Delta CDR		Feb 84
C	Changes after Delta CDR	840006	Mar 84
D	Changes to Data Format Spec., Spacelab 4 Params	840037	Aug 84
E	Changes to Data Format Spec., to reflect changes in Software.	850018	5/9/85
G	Total Revision	850030	7/15/85

IN-19579

SPECIFICATIONS

PHYSIOLOGICAL MONITORING SYSTEM

REV:	G	G	G	G	G	G	G	G	G	G	G	G	G		
PAGE:	61	62	63	64	65	66	67	68	69	70	71	72	73		
REV:	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
PAGE:	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
REV:	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
PAGE:	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
REV:	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
PAGE:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
REV:	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
PAGE:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

FSCM NO. 03652		PROJ 5348
ORIG. C T Chittenden	SRI International Menlo Park, California 94025	SPEC PMSF-20-0000-SP
PROJ. C T Chittenden		DATE 7/15/85 REV. G
Q.A.		SHEET NO. 1 of 73

SRI QA FORM 4500 5/83

FSCM NO. 03652		
PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	
DATE	7/15/85	REV. G
SHEET NO.	2 of 73	

SRI International
Menlo Park, California 94025

SPECIFICATIONS
PHYSIOLOGICAL MONITORING SYSTEM

TABLE OF CONTENTS

6.0 Notes
6.1 General Operations
6.2 General Maintenance
6.2.1 Refurbishing Battery Packs
6.2.2 Changing Fuses
6.2.2.1 EUI Power Supply Fuses
6.2.2.2 External Power Supply Fuses
6.2.3 Replacing Boards
6.3 General Handling
6.3.1 Connectors
6.3.2 Battery Pack Handling and Usage
6.3.3 Changing PROM's

SPECIFICATIONS
PHYSIOLOGICAL MONITORING SYSTEM

1.0 Scope

1.1 Description

This specification establishes the performance, design, interface, and test requirements for the Physiological Monitoring System (PMS). The PMS is a compact, microprocessor-based system, which can be worn in a pack on the body or may be mounted on a Spacelab rack or other appropriate structure. It consists of two modules, the Data Control Unit (DCU), and the Remote Control/Display Unit (RCDU). Its purpose is to collect and distribute data from physiological experiments in the Spacelab and in the Orbiter.

1.2 Classification

This specification is unclassified.

2.0 Applicable Documents

LS-30035-E, Feb. 1985, End Item Specification for Life Sciences Flight Experiment Program Physiological Monitoring System

PMSF-20-0000-QP, Quality and Reliability Plan for the Physiological Monitoring System (PMS)

PMSF-20-0000-TP, Certification and Acceptance Test Plan for the Physiological Monitoring System

PMSF-20-0000-AP, Final Acceptance Test Procedure for the Physiological Monitoring System

PMSF-20-0000-CP, Certification Procedure for the Physiological Monitoring System

PMSF-xx-xxxx-xx, flight drawings, Physiological Monitoring System

NASA Spacelab 4 Interface Control Drawings

SLD46101670 - PMS ECG Harness to Basic Parameters Module Interface
SLD46101671 - PMS to Interface Switching Panel (Digital and Analog Input)
SLD46101672 - Power Interface Document - PMS to Rack Power
SLD46101674 - Spacelab 4 PMS DCM to LSLE CDTR Model 3 Digital and Analog Data
SLD46101676 - Spacelab 4 Analog Data Input to PMS
SLD46102318 - PMS to Minioscilloscope Analog Data (ECG)

MIL-STD-490, 30 Oct. 1968, Military Standard, Specification Practices

3.0 Requirements

3.1 Item Definition

The PMS is designed to support physiological experiments in the NASA Space Shuttle program. It can support several different experiments within one configuration. Minimal reprogramming allows it to change configuration to support other experiments or changes in experiments.

The PMS system includes the Data Control Unit (DCU), which performs data acquisition, distribution, and control functions, and the Remote Control/Display Unit (RCDU), which provides user interface through pushbuttons and an LCD display. The DCU may be mounted on a surface with a bracket or it may be worn in ambulatory fashion. The RCDU is small enough to be worn on the wrist, or it can be attached with Velcro to any convenient surface. An umbilical cable joins the two units. Figure 3.1-1 is a picture of the PMS.

ORIGINAL PAGE IS
OF POOR QUALITY
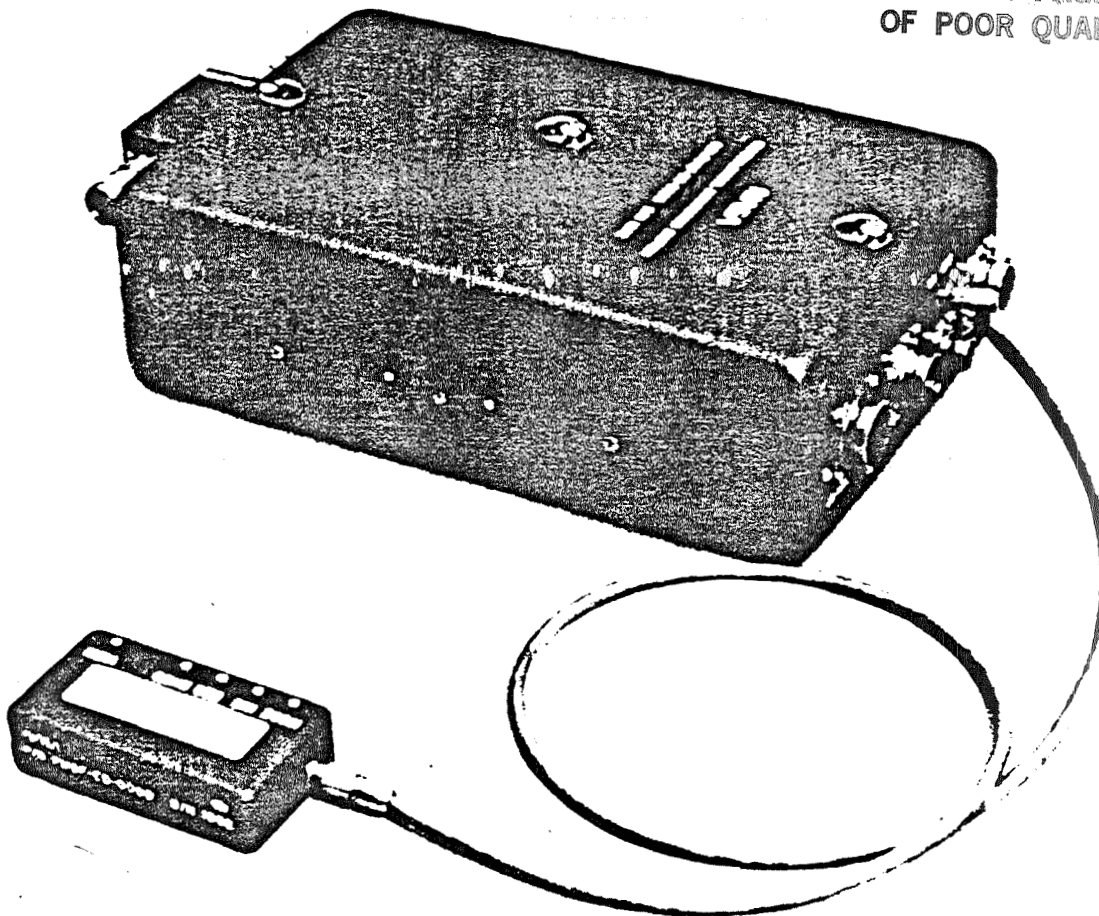
Figure 3.1-1 The Physiological Monitoring System

Three primary functions of the PMS are to automatically measure blood pressure, ECG, and heart rate. The PMS gathers four basic analog channels of ECG, Korotkov sound, filtered Korotkov sound, and cuff pressure data. A microprocessor automatically controls a blood pressure cuff and uses the data in calculating heart rate and in performing sophisticated algorithms to determine blood pressure in an ambulatory, high-artifact environment.

Another microprocessor manages the distribution of the PMS data channels. The PMS can accommodate up to eight analog input channels, including the four basic channels. An Experiment-Unique Instrumentation (EUI) interface accepts up to four additional analog channels; it also includes a serial port which can receive and transmit digital data from and to the EUI.

Additional output choices include data displayed on the RCDU; analog channels and processed or input digital data sent to the LSLE Cassette Data Tape Recorder (CDTR); and the same choices of data sent to an interface panel, with the digital data in RS-232C format. Data processed digitally and converted to analog form also may be sent to the interface panel.

A zinc-air battery pack fits inside the DCU. It can power the PMS and also provide limited power to the EUI. With the CDTR, the PMS can support and record totally self-contained ambulatory experiments. Alternatively, it can send data and obtain power through an umbilical cable which may be attached to an interface panel.

3.1.1 Item Diagrams

Figure 3.1.1-1 is a block diagram of the PMS.

3.1.2 Interface Definition

3.1.2.1 Electrical and Power Interfaces

3.1.2.1.1 Connector Pin Assignments

For Spacelab 4, the connector pin assignments are described in the NASA Spacelab 4 Interface Control Documents. Howevever, the PMS data inputs and outputs are more general and flexible than the ICD's show. Table 3.1.2-1 lists all the external PMS connectors and their pin assignments. All contact sizes are 22D, except for the Rack Power connector (J1), which has size 16 contacts. Circuit class is per MSFC-SPEC-521, Table 2.

SRI International
Menlo Park, California 94025

FSCM NO. 03652	
PROJ. NO.	5348
SPEC. NO.	PMSF-20-0000-SP
DATE	7/15/85	REV. G
SHEET NO.	8 of 73

REMOTE CONTROL/DISPLAY MODULE (RCDM)

UP TO 4 CONTROL PUSHBUTTONS
2 LINE, 32 CHARACTER DISPLAY

DISPLAY DATA
CONTROL DATA

MUX'D DATA — TO RACK
MUX'D DATA — TO CDTR
CLOCK
POWER

0-5V ANLG DATA — TO RACK
0-5V ANLG DATA — TO CDTR (CASSETTE DATA TAPE RECORDER)

DATA CONTROL MODULE (DCM)

• CONTROL PROCESSOR (CP)
  MICROPROCESSOR
  MEMORY
  INTERRUPT CONTROL
  TIMERS
  A/D INPUT
  D/A OUTPUT
  DIGITAL I/O
  SERIAL TO CDTR
  SERIAL TO/FROM RCDM
  SERIAL TO/FROM DP
  R-232 TO RACK
  SERIAL TO/FROM EUI

• ANALOG INTERFACE
  BUFFERS
  OFFSET AMPS
  A/D CONVERTERS/MUXES
  D/A CONVERTER
  HEADPHONE AMP

• DATA PROCESSOR (DP)
  MICROPROCESSOR
  MEMORY
  INTERRUPT CONTROL
  TIMERS
  A/D INPUT
  DIGITAL I/O
  SERIAL TO/FROM CP
  PARALLEL TO/FROM BPM

DIGITAL DATA
CALIBRATION CONTROL
ANALOG DATA (UP TO 5 CHANNELS)
POWER

TO EUI
(EXPERIMENT UNIQUE INSTRUMENTATION)

POWER
ANLG DATA (5 CHNS)
CUFF CONTROL SIGNALS
POWER

BASIC PARAMETERS MODULE

ECG AMP
KOROTKOV SOUND AMP
CUFF PRESSURE TRANSDUCER AMP
R-WAVE PEAK DETECTOR
K-SOUND PEAK DETECTOR
CUFF CONTROL PNEUMATICS & ELECTRONICS

POWER MODULE

DC-DC CONVERTERS
BATTERY PACK
LOW VOLTAGE SENSORS

+28V
FROM RACK

Figure 3.1.1-1 PMS Block Diagram

ORIGINAL PAGE IS
OF POOR QUALITY

Table 3.1.2-1 External PMS Connectors

Connector	Name/Type	Pin No.	Function	Amps Volts	Circuit Class
J1	Rack Power	A	+28V DC Power	2A	I
	MS27508E12F4P	B	Power Return	2A	I
		C	Chassis Ground	-	
		D	Not Connected		
J3	Rack Data	1	Analog 1 Cuff Pressure	0-5V	III
	MS27508E14F35S	2	Analog 1 Cuff Return	0-5V	III
		19	Shield	0-5V	III
		15	Analog 2 ECG Sig	0-5V	III
		16	Analog 2 ECG Return	0-5V	III
		29	Shield	0-5V	III
		12	Analog 3 K-Snd Sig	0-5V	III
		13	Analog 3 K-Snd Return	0-5V	III
		26	Shield	0-5V	III
		6	Digital Data Output	+/-5V	IV
		7	Digital Data Return	+/-5V	IV
		23	Shield	+/-5V	IV
		3	Analog Ch 4 Data[1]	0-5V	III
		20	Analog Ch 4 Return	0-5V	III
		21	Shield	0-5V	III
		17	Analog Ch 5 Data	0-5V	III
		18	Analog Ch 5 Return	0-5V	III
		30	Shield	0-5V	III
		14	Analog Ch 6 Data	0-5V	III
		28	Analog Ch 6 Return	0-5V	III
		27	Shield	0-5V	III
		11	Analog Ch 7 Data[2]	0-5V	III
		10	Analog Ch 7 Return	0-5V	III
		25	Shield	0-5V	III
		37	Analog Ch 8 Data[3]	0-5V	III
		34	Analog Ch 8 Return	0-5V	III
		33	Shield	0-5V	III
		8	Data Ready	+/-5V	IV
		9	Data Ready Return	+/-5V	IV
		24	Shield	+/-5V	IV
		5	Digital Input	+/-5V	IV
		22	Digital Return	+/-5V	IV
		4	Shield	+/-5V	IV
		36	DAC Signal	0-5V	III
		31	DAC Sig Return	0-5V	III
		32	Shield	0-5V	III

Notes:
1. jumpered for filtered K-Snd
2. jumpered for filtered K-Snd
3. jumpered for Ref. Cuff Pressure

Table 3.1.2-1 External PMS Connectors
continued

Connector	Name/Type	Pin No.	Function	Amps Volts	Circuit Class
J4	CDTR	1	Ch 1 Cuff Press	0-5V	III
	MS27508E12F35PA	2	Ch 2 ECG	0-5V	III
		3	Ch 3 k-Snd	0-5V	III
		4	Ch 4 Data[1]	0-5V	III
		5	Ch 5 Data	0-5V	III
		6	Ch 6 Data[2]	0-5V	III
		7	Ch 7 Data[3]	0-5V	III
		8	Ch 8 Data	0-5V	III
		9	Ground Analog Return	0-5V	III
		10	V Battery In	0-9V	II
		11	Ground, Power	0-9V	II
		12	V Battery Out	0-9V	II
		13	Ground, Power	0-9V	II
		17	Shield, Analog	0-5V	
		18	Serial Data Clock In	0-5V	IV
		19	Serial Data Output	0-5V	IV
		20	Framing Sync Input	0-5V	IV
		21	Ground, Digital	0-5V	IV
		22	Shield, Digital	0-5V	

Notes:
1 - jumpered for filtered K-Snd
2 - jumpered for filtered K-Snd
3 - jumpered for Ref Cuff Pressure

Connector	Name/Type	Pin No.	Function	Amps Volts	Circuit Class
J5	Subject	1	ECG Signal UC -		III
	Harness	2	ECG Signal LC +		III
	MS27508E12F35S	15	ECG Ground		III
		3	Shield - ECG		III
		5	K-Snd Signal +		III
		6	K-Snd Signal -		III
		7	Shield K-Snd		III
		9	Cuff Press. sig +		III
		10	Cuff Press. sig -		III
		11	Cuff Press. bias +		III
		20	Cuff Press. bias -		III
		19	Shield-Cuff Press.		III
		18	Unreg -		III
		22	Aux Valve Control		III
		16	Shield-Valve		III

Table 3.1.2-1 External PMS Connectors
continued

Connector	Name/Type	Pin No.	Function	Amps Volts	Circuit Class
J6	EUI	7	Digital Data Input	0-5V	IV
	MS27508E14F35SA	8	Dig. Data In Control	0-5V	IV
		23	Dig. Input Sig Return	0-5V	IV
		6	Shield, Dig. Data In	0-5V	IV
		10	Digital Data Output	0-5V	IV
		11	Dig. Data Out Control	0-5V	IV
		25	Dig. Data Out Sig Ret.	0-5V	IV
		9	Shield, Digital Out	0-5V	IV
		26	Calibrate Signal Out	0-5V	IV
		27	Calibrate Sig Return	0-5V	IV
		32	Power Line Shield		
		33	Power for Ext. Sensors	+10VDC	II
		34	Power Return		
		1	Analog Ch. 1 (Reserved)		III
		2	Analog Ch. 1 Return		III
		15	Analog Ch. 2 (Reserved)		III
		16	Analog Ch. 2 Return		III
		17	Analog Ch. 3 (Reserved)		III
		18	Analog Ch. 3 Return		III
		3	Analog Ch. 4 Data	0-5V±2.5V	III
		4	Analog Ch. 4 Return	"	III
		28	Analog Ch. 5 Data		III
		29	Analog Ch. 5 Return	"	III
		30	Analog Ch. 6 Data	"	III
		19	Analog Ch. 6 Return	"	III
		20	Analog Ch. 7 Data	"	III
		21	Analog Ch. 7 Return	"	III
		36	Analog Ch. 8 Data	"	III
		31	Analog Ch. 8 Return	"	III
		37	Analog Shield		
		35	Neg Power for Ext. Sensors	-10VDC	II

3.1.2.1.2 Jumper Configurations

There are ten jumpers on the Analog Board (PMSF-DC-AN00) for configuring the eight analog input offset buffers that drive the PMS control processor, the rack interface buffers, and the CDTR interface buffers. Each jumper location has three solder terminals in a row. The center terminals are labelled on the PMSF-DC-AN00-SC, sheet 1 drawing and on the board, with "CH" followed by the respective channel number for the eight jumper groups, and "IN" and the channel number for the two jumper groups, described below. The jumpers are made using bare wire and installed by soldering from the center terminal to one of the two adjacent terminals.

Eight jumpers, one for each channel, select the ground return reference for the input buffers, either the internal system ground, using terminals labelled G on the drawing and on the board, or the external ground return from the EUI, EG on the drawing and blank on the board. Any channel which is generated internal to the PMS should have its ground return jumpered to G, and any channel generated from the EUI should have its ground return jumpered to EG.

Two jumpers are provided to select the inputs to channels 7 and 8, either from the EUI, using terminals labelled IN E, or from the PMS basic parameters (BP) section, labelled IN B. Selecting the BP configuration causes two channels generated internal to the PMS to be selected as channels 7 and 8. Channel 7 is the filtered Korotkov sounds, and channel 8 is the reference cuff pressure. Selecting the EUI configuration allows channels 7 and 8 to be input from the EUI.

On the PMS motherboard, the first three channel inputs from the EUI are wired in parallel with three inputs from the BP section (cuff pressure, ECG, and Korotkov sounds, respectively), and on the Analog board the EUI channel 4 input is wired in parallel with a fourth input (filtered Korotkov sounds) from the BP section. The four BP signals are therefore available to the EUI; however, the EUI must not drive the first three channels as long as the BP boards are used, or channel 4 as long as the wire on the Analog Board is in place. This leaves four channels which may be used as input from the EUI: channels 5 and 6, and channels 7 and 8 if jumpered for EUI input.

3.1.2.1.3 External Power Input

The PMS can obtain power from an unregulated 28 vdc supply. It requires up to 5 watts continuous power, when the blood pressure pneumatics are not functioning. During blood pressure data collection, up to 16 watts may be required by the pump and valves. As it starts inflating the cuff, the pump also requires a transient spike of power of up to 50 watts for up to 50 msec.

3.1.2.1.4 Battery Power

The DCU Battery Pack consists of 20 stacks of Gould HP630 zinc-air battery cells. Eleven stacks are paralleled on the positive (V+) side and nine stacks are paralleled on the negative (V-) side. The cells are stacked with 7 cells in series. The minimum voltage put out by any one cell is around 1.1 v; therefore the operating voltage obtained from a stack of 7 cells in series ranges from around 8.5 v to around 7.7 v (cutoff). Average operating currents should be around 200 ma for the V+ side and around 100 ma for the V- side. The battery can supply considerably more current than this during short bursts, for instance, while the pump is running.

The total capacity of a battery pack is around 10 ampere hours for the V+ side, and around 8.5 ampere hours for the V- side. This translates to around 50 hours of operating time. (Tests have shown that after the specified 30 hours of operating time, little if any deterioration can be measured in a battery pack.)

The battery has three outputs: V+, V- and ground (COM). A fourth pin in the battery connector is not connected. PMS circuitry needing more than 7.7 v, such as the pump and the valves, uses the voltage difference between V+ and V-. The other circuitry uses the difference between V+ or V- and ground, as necessary.

The PMS has circuitry which senses when the voltage from the battery pack becomes too low. When this occurs the message "LOW DC" appears in the upper left corner of the RCDU. The message remains until that area of the display needs to be used for a different message. If the voltage level has remained low, the same message will reappear at 15 seconds intervals. It is most likely that the message will first appear during operation of the cuff inflation pump, since the PMS needs more power then.

Zinc-air batteries have a very flat discharge curve. The voltage output remains constant until very close to the end of the battery life. Therefore it is important to change the battery pack shortly after the "LOW DC" message appears.

3.1.2.1.5 EUI Power Output

Power is provided by the PMS through the EUI connector to be used by external sensors. The plus and minus unregulated voltage is output. These voltages will vary according to whether the battery pack or an external power source is used. If external power is used, it will be around plus and minus 14 vdc; unregulated voltage from the battery pack will vary from plus and minus 10 vdc to around plus and minus 8 vdc.

FSCM NO. 03652	
PROJ. NO. 5348	
SPEC. NO. PMSF-20-0000-CP	
DATE 7/15/85	REV. G
SHEET NO. 14 of 73	

SRI International
Menlo Park, California 94025

While battery powered, the PMS is able to supply up to 1/2 watt to the EUI and still maintain its functionality, as long as blood pressure measurements are not taken any more often than once every 10 minutes. (It should be possible to take two measurements in close proximity as long as at least 10 minutes have passed since the previous measurements.) This restriction is necessary in order for the zinc air battery cells to regain effectiveness lost because of air starvation.

As a protection to the PMS circuitry, the EUI power circuit should be fused at 1/4 amp if the PMS power output is used.

3.1.2.2 Physical Interfaces

3.1.2.2.1 Connector and Switch Locations

The PMS has six functional external electrical connectors and one pneumatics connector. On the Appendage End Plate are the Subject Harness Connector (J5), the EUI Connector (J6), and the pneumatics connector to the subject harness (AIR). A headphone connector also is located on the Appendage End Plate, but it is not functional. The locations of these connectors can be seen on the assembly drawing for the Appendage End Plate (PMSF-DC-1800-AD).

The Connector End Plate has the RCDU Connector (J2), the CDTR Connector (J4), the Rack Data Connector (J3), and the Rack Power Connector (J1). The locations of these connectors can be seen on the assembly drawing for the Connector End Plate (PMSF-DC-1800-AD). The PMS has one switch, which is on the Connector End Plate. It is used for turning the battery power on and off.

3.1.2.2.2 Bracket Holes

Four bracket holes are located on the DCU Card Cover Assembly, one in each corner. These are provided so that a bracket can be used to attach the PMS to other surfaces. See assembly drawing PMSF-DC-1200-AD for details.

3.1.2.2.3 Air Holes

Air holes are located in between the connectors on the Connector End Plate. They are covered with screening to keep particles out of the interior of the DCU while allowing air to enter so that the battery will get enough oxygen for proper functioning. It is important not to impede the free flow of air by covering these air holes.

3.1.2.2.4   Battery Location and Installation

The battery pack assembly is located in the DCU Battery Box
(PMSF-DC-2006) beneath the DCU Battery Cover Assembly (PMSF-DC-1100).
The battery cover is removed by loosening the three quarter-turn
fasteners on the outside of the cover and lifting the cover (see
assembly drawing PMSF-DC-1100-AD).

Prior to installation of the battery pack, turn off the battery
power switch on the connector end plate. Then place the battery
assembly in the battery well, with the connector cable protruding
through the cutout next to the well. Ensure that the battery pack is
installed in the proper orientation. The connector cable should
emerge from the top of the pouch right next to the loop on the side of
the battery pouch and should be passed through the loop. This loop
should be adjacent to the cutout next to the well. Mate the battery
connector (P151) to the connector visible through this cutout (J151),
orienting the connector so that the cable end points toward the
battery pack, as shown in Figure 3.1.2.2-1. Replace the DCU cover by
putting it back on and tightening the quarter turn fasteners. Note:
the DCU cover will only fit one way. The center fastener is offset to
one side.


```
Battery          Loop          Cable End
  Well         Location        of Connector
```
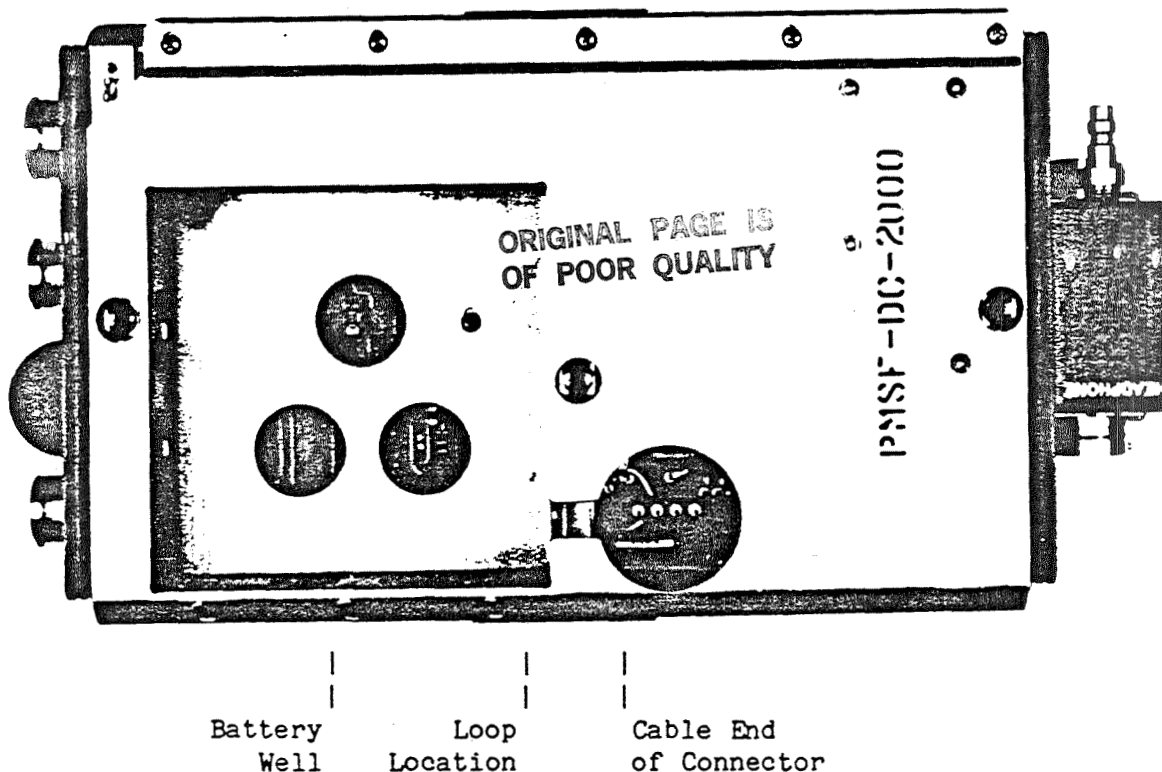
Figure 3.1.2.2-1   Battery Orientation

Turn the battery switch to the ON position to use the battery
power. After the battery is installed, the PMS still may be run off
of external power by turning the switch to the OFF position and
supplying power through the Rack Power Connector. An operating time
log should be maintained to ensure that the maximum operating time is
not exceeded.

3.1.2.2.5 Subject Harness Exchangeability (Pressure Transducer Calibration)

The blood pressure pneumatics and electronics contain two cuff pressure transducers. The "primary" transducer is in the subject harness. It is positioned close to the cuff in order to produce readings that are as accurate and timely as possible. The "reference" transducer is situated in the DCU. It is not as high quality as the primary transducer and has a slow response, since it is at the opposite end of a long air column from the cuff.

It is possible to calibrate the reference transducer exactly during assembly, since it is an integral part of the DCU. However, a one-time calibration of the primary transducer in any particular subject harness is impossible unless that harness is to be used exclusively with one particular DCU. In order to allow the subject harnesses to be interchangeable between various DCUs, the primary transducer should be calibrated dynamically each time the PMS is turned on.

The reference transducer is calibrated to measure 0 mmHg at 0v, and 256 mmHg at 5v.

The primary transducer is calibrated against the reference transducer whenever a "calibrate" command is given to the PMS. The Control Processor receives the command and transmits it to the Data Processor, which causes the cuff to inflate to a reasonably high pressure (normally around 200 mmHg), allows the reference transducer to stabilize by waiting about two seconds, then takes simultaneous readings of the primary (CPP_high) and reference (CPR_high) transducers.

The Data Processor then deflates the cuff to a relatively low pressure (normally around 50 mmHg), allows it to stabilize for about two seconds, then takes simultaneous readings of the primary (CPP_low) and reference (CPR_low) transducers before allowing pressure to be dumped from the cuff. Monitoring of the pressures is done solely with the reference transducer during the calibration.

The values acquired at the high and low pressures are used to define a straight line passing through the two sets of coordinates (CPR_high, CPP_high) and (CPR_low, CPP_low). The slope of the line is the scale factor to be applied to the primary transducer reading, and the y-intercept is the offset to be applied to the reading, to convert the primary readings to mmHg, e.g.,

$$CP = m * CPP + b$$

$$m = (CPR\_high - CPR\_low)/(CPP\_high - CPP\_low)$$

$$b = CPR\_high - m * CPP\_high.$$

Once the primary transducer is calibrated, it is used in all cuff pressure measurements by the Data Processor. The expected range of cuff pressures is from 0 to 255 mmHg. Because the transducer data is A/D converted into 10 bits, allowing a range of 1024 units, one mmHg is represented in the computer memory as 4 units. The conversion in the equations above is performed to convert the primary data into mmHg/4.

The Data Processor transmits the calibration factors to the Control Processor, which uses them to calibrate the digital cuff pressure data it outputs to the DAC.

The user may calibrate the device receiving the DAC output (i.e., a strip chart recorder) by noting the reference transducer data output to the display at the end of each calibration plateau. This display is described in section 3.1.2.3.7.2.1. The same data is available to the user through a digital interface as type 10 data, described in section 3.1.2.3.1. The reference transducer data units are mmHg/4, e.g., a value of 796 indicates 199 mmHg.

The scale factor (m) and offset (b) are made available to the user as described in the General Data Format Specifications, Section 3.1.2.3.1. These should be applied to digital primary cuff pressure transducer data as described above, to convert the data into mmHg.

FSCM NO. 03652	
PROJ. NO. 5348	
SPEC. NO. PMSF-20-0000-SP	
DATE 7/15/85	REV. G
SHEET NO. 18 of 73	

SRI International
Menlo Park, California 94025

3.1.2.3 Digital Data Interfaces

3.1.2.3.1 General Data Format Specifications

3.1.2.3.1.1 Introduction

This section describes the data formats to be used by the PMS. Data can be transmitted and received from a variety of input and output devices including an RS-232C link, the Cassette Data Tape Recorder (CDTR), A-to-D Converters, and a digital serial data port from the Experiment Unique Instrumentation (EUI).

The general design of the PMS data format specification was motivated by the following goals:

o Consistency across interfaces. The same general encoding scheme should be used by all digital interfaces.

o Ease of decoding. It should be relatively simple to decode data in almost any programming language, whether this is performed in real time by the LSLE microcomputer or offline by a large mainframe computer. Thus, bit-packing schemes are avoided in favor of byte-aligned data.

o Reliability. The encoding scheme should provide an extra layer of reliability to assure the user that the data is being recovered correctly.

o Data type independence. The scheme should be universal so that programs can be written to decode a selected subset of the data without needing knowledge of all the data formats being used.

o Extensibility. The formatting method should be extensible so that new data types or events can be added at a future time without disturbing previously written software.

3.1.2.3.1.2 Data Block Format

All data transmissions occur in encoded blocks with a standard format, as follows:

```
+------+------+------+------+-------///-------+
| Sync |   Length    | Type | Data0 ... DataN |
+------+------+------+------+-------///-------+
```

All four of the above data fields are aligned on byte boundaries for simplicity of decoding. The encoding of each field is as follows:

o A Sync byte (ASCII SYN, hexadecimal 16) precedes the data block. This byte provides assurance that the decoder is in proper alignment with the data block.

o A two-byte length field, transmitted least significant byte first. This field contains the length, in bytes, of the following data, including the type byte. For compatibility with the LSLE microcomputer, the data section of a block will never exceed 4,096 bytes.

o A one-byte type field, containing the data type, as enumerated in section 4. This number indicates the type (and hence encoding scheme) of the data contained in the data block.

o The data bytes. Zero or more bytes of data may follow and will be encoded in an arbitrary format depending on the type of data enclosed in the block.

This scheme entails four bytes of overhead, but provides several benefits. Because of the byte alignment of the data block, it should be relatively simple to write a single program in most programming languages to decode the data block. It is possible to select only those data types of interest simply by inspection of the type field, without need to know the internal structure of any field. The number of data types is extensible up to 256 different types. Finally, the Sync byte and length mechanism provide some additional assurance that the data is being recovered successfully.

SRI International
Menlo Park, California 94025

FSCM NO. 03652		
PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	
DATE	7/15/85	REV. G
SHEET NO.	20 of 73	

3.1.2.3.1.3 Enumerated Data Types

This section enumerates the data types, and the internal
structure of the corresponding data field, for the needs of SL4. In
the future additional types may be specified and assigned numbers
without disturbing the already enumerated types and existing decoding
software. Some of the data types actually indicate events that have
occurred, rather than (or in addition to) conveying data. For clarity
the data types are illustrated without the preceding Sync or Length
fields.

3.1.2.3.1.3.1 Power On event

```
+---+
| 0 |
+---+
```

This data type has a type field of zero and no subsequent
data bytes. It indicates that the PMS has just been powered
on and the system has been reset.

3.1.2.3.1.3.2 Experiment Identification

```
+---+----------///----+-------///----+
| 1 | Experiment Name | Subject Name |
+---+----------///----+-------///----+
```

This data type has a type field of one, and two fields
in the data section. The first field is 6 bytes in
length and contains the experiment name; the second field
is 10 bytes in length and contains the subject name.
Each field is encoded as a left-justified string of ASCII
characters padded with trailing blanks; the most significant
bit of each character is reset. This data type indicates
a change in the experiment and/or subject. It will be
transmitted to the RS-232C link and to the CDTR when the
operator has keyed in a new experiment and/or subject number.

3.1.2.3.1.3.3 Subject Parameters

```
+---+--------+---------+---------+-----------+---------+--------+
| 2 | T$MAX  | CP$MAX  | CP$MIN  | KS$MIN    | SLOPE   | CODE   |
+---+--------+---------+---------+-----------+---------+--------+
```

This data type has a type field of two, and six
fields in the data section, each one byte in length.
This data type indicates a change in one or more
of the experimental parameters governing the blood
pressure and/or heart rate measurement algorithms.
The parameters are as follows:

    T$MAX - Maximum time for any deflation, in
             seconds. One-byte unsigned integer.

    CP$MAX - Maximum cuff pressure for any deflation,
             in millimeters of mercury. One-byte
             unsigned integer.

    CP$MIN - Minimum cuff pressure for any deflation,
             in millimeters of mercury. One-byte
             unsigned integer.

    KS$MIN - Minimum number of K-sound peaks needed to
             determine blood pressure. One-byte unsigned
             integer.

    SLOPE - Nominal RK slope for the subject, in
             nsec/mmHg. One-byte positive fixed-
             point number with 4 bits of integer
             and 4 bits of fraction.

    CODE   - Choice selection code for up to 8 choices.
             Eight bits, one for each choice, where b7
             is MSB and b0 is LSB. Each bit defaults to 0.
             Choice table:

                 b7 - 1 if raw K-sounds in DAC output;
                      0 if filtered.
                 b6 - 1 if fourth phase diastolic displayed
                      with fifth phase; 0 if not.
                 b5 - 1 if no software valve windowing;
                      0 if windowing.
                 b4 to b0 - undefined

Heart Rate Information

```
+---+------------+-------+
| 3 | Heart Rate | Beats |
+---+------------+-------+
```

This data type has a type field of three and two fields in the
data section, each one byte in length. The Heart Rate field is
the integer (0 to 255) number of beats per minute as measured
by the Data Processor. The Beats field indicates the number of
beats in the Heart Rate measurement: a zero indicates a one
beat, or instantaneous, measurement; a one indicates averaging
over the last four beats. The Heart Rate Information data type
is transmitted each time this information is updated, either
once per beat or once per four beats.

3.1.2.3.1.3.5   Calibration Information

```
+---+------------+------------+------------+------------+
| 4 | Scale LSB  | Scale MSB  | Offset LSB | Offset MSB |
+---+------------+------------+------------+------------+
```

This data type has a type field of four and two fields in the
data section, each two bytes in length. It indicates that a
calibration event has just taken place. The data fields
contain the scale and offset values to be applied to the
primary cuff pressure transducer data, as reported by the Data
Processor. The scale field is encoded as a positive fixed-
point number with the MSB the integer part and the LSB the
fractional part (iiiiiiii.ffffffff). The offset field is
encoded as a two's complement, signed integer in the range
+32767 to -32768.

3.1.2.3.1.3.6   Blood Pressure Information

```
+---+------------+-------------+-------------+------------+
| 5 | Systolic   | Diastolic 4 | Diastolic 5 | Mode/Error |
+---+------------+-------------+-------------+------------+
```

This data type has a type field of five, and four one-byte
fields in the data section. The first three data fields give
the systolic, fourth phase, and fifth phase diastolic blood
pressure in mm Hg (integer 0 to 255). The fourth field is the
mode/error code. Bit 7 reflects mode: 1 if continuous bleed,
0 if automatic. Bits 6 to 0 contain a 7-bit byte with default
value of 0, defining any errors in blood pressure measurement
as follows:

            0 - no error
            1 - too few K-sounds to process
            2 - pulse pressure below minimum or negative
            3 - slope negative
            4 - not enough K-sounds left after processing
            5 - bad cuff pressure data in test mode
            6 - bad RK interval data in test mode

3.1.2.3.1.3.7   Blood Pressure Abort

```
+---+--------+
| 6 | Reason |
+---+--------+
```

This data type has a type field of six, followed
by one field of one byte in length. This data type
indicates that a cuff inflation/deflation cycle
was aborted; the data field gives the reason for
the cancellation of the cycle:

> 0 -   The cycle was aborted at the request of
>   the operator.
>
> 1 -   An over-time or over-pressure condition
>   was detected by the cuff electronics.
>
> 2 -   A loss of transducer reference voltage
>   occurred.
>
> 3 -   A loss of ECG signal occurred.
>
> 4 -   An inflation over-time condition was
>   detected by the Data Processor software.

3.1.2.3.1.3.8   ADC Channel Data

```
+---+----------------+-------///-------+
| 7 | Channel Number | Data0 ... DataN |
+---+----------------+-------///-------+
```

This data type has a type field of seven, followed by
a variable number of bytes of data. The first data
byte indicates the Analog-to-Digital Converter (ADC)
channel (1 to 8) from which the block originated.
The subsequent block of bytes contains the samples
processed by the PMS Control Processor as specified in
the PMS parameter EPROM. Such processing may include
scaling and addition of an offset.

SRI International Menlo Park, California 94025	FSCM NO. 03652	
	PROJ. NO. 5348	
	SPEC. NO. PMSF-20-0000-SP	
	DATE 7/15/85	REV. G
	SHEET NO. 24 of 73	

3.1.2.3.1.3.9 EUI Channel Data

```
+---+-------///-------+
| 8 | Data0 ... DataN |
+---+-------///-------+
```

This data type has a type field of eight, followed by
a variable number of bytes of data. This data type
contains the data from the EUI digital data port.
A flag in the PMS parameter EPROM will determine
whether the EUI data itself is encoded in the same
format. If the EUI lacks appropriate software or
processing capability, the EUI will present data
with appropriate handshaking; the PMS will buffer
the block until a fixed number of bytes have been
received, and then transmit it in the above format
to the CDTR and/or RS-232C link. If the EUI has the
appropriate encoding software, the PMS will observe
the length byte as presented by the EUI in order to
determine when to transmit the buffer onwards.

3.1.2.3.1.3.10 Valve Control Information

```
+---+----------+
| 9 | Control  |
+---+----------+
```

This data type has a type field of nine, followed by
one byte of data indicating that the bleed valve has
been given a control command. The control byte has
two values: open (zero), or close (one).

3.1.2.3.1.3.11 Cuff Pressure Transducer Data

```
+----+-----------+-----------+-------------+-------------+
| 10 |Primary LSB|Primary MSB|Reference LSB|Reference MSB|
+----+-----------+-----------+-------------+-------------+
```

This data type has a type field of ten, followed by four
bytes of data. The first two data bytes are the LSB and MSB
of the 10-bit uncalibrated value read from the primary
transducer, and the last two are the LSB and MSB of the
10-bit value read from the reference transducer at the same
time. These values are used during the cuff pressure
primary transducer calibration. The most significant 6 bits
of the primary MSB and of the reference MSB should be ignored,
except for bit 7 of the primary MSB. This bit is used as a
flag; 1 indicates that the values occurred at the top
calibration level (the first of the two calibration points),
and 0 means they occurred at the bottom calibration level.

SRI International
Menlo Park, California 94025

FSCM NO. 03652
PROJ. NO.   5348
SPEC. NO.   PMSF-20-0000-SP
DATE   7/15/85   REV. G
SHEET NO.   25 of 73

3.1.2.3.1.3.12   Calibrated Primary Cuff Pressure

```
+----+---------------+
| 11 | Cuff Pressure |
+----+---------------+
```

This data type has a type field of eleven, followed by one
byte of data. The data is an unsigned byte representing
cuff pressure in mmHg as determined from calibrating the
input from the primary transducer.

3.1.2.3.1.3.13   Data Type 12 has been deleted.

3.1.2.3.1.3.14   Battery Low Indicator

```
+----+
| 13 |
+----+
```

This data type has a type field of thirteen and no
subsequent data bytes. It indicates that low voltage
has been sensed on the power lines.

3.1.2.3.1.3.15   Korotkov Sound Gain

```
+----+------+
| 14 | Gain |
+----+------+
```

This data type has a type field of fourteen, followed by one
byte of gain data. The data is an integer from 1 to 4,
representing the one of four possible gain setting for the
K-sound amplifier that is currently to be used.

3.1.2.3.2 RS-232C Data Interface

3.1.2.3.2.1 Transmitted Data

RS-232C data is transmitted through the Rack Data Connector on the Digital Data Output line. The transmission is in encoded blocks with the standard data block format. A Data Ready line is raised for a delay period of two character times before the output of valid data and remains raised until the last bit of data has been transmitted. From one to several blocks of data may be transmitted while the Data Ready line is raised, depending on the data rate.

Two invalid characters are transmitted during the delay period. These should be ignored. The start of valid data always is indicated by a SYN character (hexadecimal 16).

Any data type described in the data format specifications may be sent through the RS-232C link. The actual data to be transmitted for any experiment is chosen during the programming of the Parameter PROM.

3.1.2.3.2.2 Received Data

The UART used as a transmitter also can be used as a receiver, and Digital Data Input and Return lines are available in the Rack Data Connector. Note that although the receiver is designed to be RS-232C compatible, it will not meet a 100 kohm input impdedance requirement. If ground loops were a problem, an optoisolator with a small power converter to provide power to drive the input to the PMS could be added to the rack interface.

The PMS is not programmed currently to receive RS-232C data. If such input were needed in the future, the reprogramming would be straightforward.

3.1.2.3.2.3 Variable Baud Rate

The baud rate for the transmission is software controllable. The current software programs the RS-232C UART for a rate of 9600 baud. There are 12 other possible rates ranging between 75 baud and 4800 baud.

3.1.2.3.3 Digital-to-Analog Converter

3.1.2.3.3.1 General Characteristics

A Digital-to-Analog converter (DAC) is one of the output ports of the Control Processor. Ten bits of data are converted to a 0 to 5v output which goes through the Rack Data Connector. The DAC control program is structured such that any digital data available to the Control Processor could be output through the DAC. Simple digital processing, including scaling, offsetting, and summing, can be performed on the data channels used. The output data rate for a channel would be the rate at which that channel had been input (maximum of 800 samples/ sec).

3.1.2.3.3.2 Use in Spacelab 4

For SL4 the cuff pressure is scaled and offset with the calibration factors determined by the Data Processor, then summed with Korotkov sound data. The Korotkov sound data can be chosen by the operator to be either filtered or unfiltered, with bleed valve noise either windowed out by software or left as it comes from the analog circuitry. (Most of the valve noise is windowed out by a sample-and-hold in the circuitry which is activated when the valve is opened and closed shortly after the valve is closed.)

The summed data stream is output to the DAC at a rate of 400 samples/sec. The output is delayed by 30 msec, due to internal buffering by the Control Processor. The program clips the summed data at 0 v and at 5 v, so that no wrap-around occurs if the sum is off-scale.

3.1.2.3.4 Analog-to-Digital Converters

3.1.2.3.4.1 General Characteristics

The PMS has two 10-bit ADC's, with an input range of 0 to 5 v. One inputs to the Data Processor and one to the Control Processor. Both converters are preceded by an 8-channel multiplexor and a sample-and-hold. Each processor controls its own multiplexor and may choose to sample any combination of channels.

The analog signals may start out either as 0 v to 5 v signals or as -2.5 v to +2.5 v signals. The latter must be offset to the 0 v to 5 v level before being input to the multiplexor. To accomplish this the processor programs an offset amplifier provided for each channel.

SRI International
Menlo Park, California 94025

FSCM NO. 03652
PROJ. NO.   5348
SPEC. NO.   PMSF-20-0000-SP
DATE   7/15/85   REV. G
SHEET NO.   28 of 73

3.1.2.3.4.2 Control Processor ADC

All eight possible analog channels (4 from the EUI, and 4 from
the BP section of the PMS) are input to the multiplexor for the
Control Processor. The channel assignments are as follows:

Channel	Data
1	Cuff pressure
2	ECG
3	Korotkov sounds
4	Filtered Korotkov sounds
5	EUI data
6	EUI data
7	EUI data or filtered Korotkov sounds (jumperable)
8	EUI data or reference cuff pressure (jumperable)

3.1.2.3.4.3 Data Processor ADC

The Data Processor currently uses only three channels. The
channel assignments follow:

Channel	Data
1	Cuff pressure (controlled by the Control Processor)
7	Filtered Korotkov sounds
8	Reference cuff pressure

3.1.2.3.4.4 Uses in Spacelab 4

The Control Processor uses its ADC to digitize cuff pressure
and either filtered or unfiltered Korotkov sounds, depending on the
operator's choice. It passes the data to the DAC routines to create
the summed data output. If the software windowing option is chosen,
the Control Processor ADC routine starts holding the last Korotkov
sound data point as soon as the Data Processor tells it that the bleed
valve is open, then resumes sampling when the Data Processor tells it
that the valve is closed.

The Data Processor uses the cuff pressure and reference cuff
pressure channels in the calibration of the cuff pressure transducer.
Then it uses the cuff pressure and the filtered Korotkov sound
channels in the determination of blood pressure.

3.1.2.3.5 EUI Digital Data Interface

A serial link exists for transfer of digital data between the PMS and the EUI through the EUI serial link. The hardware has been incorporated as a UART connected to the Control Processor. Although diagnostic routines have been run to determine that the hardware functions correctly, no software currently is available to accept or to transmit EUI digital data.

3.1.2.3.5.1 Data format

Any of the data types described in the data format specifications can be used for input or output. However, since EUI equipment is unlikely to have enough capability to produce digital data according to the specified formats, a special format was designed for EUI intput. Data type 8 was designed specifically for digital data of an arbitrary length, without the proper formatting demanded in the other data types. See section 3.1.2.3.1 for further details.

3.1.2.3.5.2 EUI Interface Circuitry

The EUI Digital Data Interface is a full-duplex, serial channel communicating with a standard asynchronous protocol of start bit, data bits, and stop bit(s). The peripheral controller is the same Harris 82C52 Serial Communications Interface that is employed for the RS-232C Data Interface, described in Section 3.1.2.3.2. Although the EUI interface can be programmed over the same range of baud rates that are available for the RS-232C Data Interface, it will usually be restricted to the lower rates to conserve power in the opto-isolator interface circuits. Recommended parameters to use in programming the interface are indicated in the following table:

Start Bits	1
Data Length	8 bits
Parity	None
Stop Bits	2
Baud Rate	1200 bps.

Since this channel is not used on SLS-1, drivers for this interface are not included in the EPROM of the Control Processor. These drivers can be added at a later time and the parameters of the link can be modified, if desired.

The output signal is at the CMOS levels of the Processor's power supply and will be at, nominally, 0 Volts and +5 Volts DC for logic values of 0 and 1, respectively. The source impedance is approximately 6 Kohms and is largely set by a series resistor (R7) for circuit protection. The idle state of the output is the logic 1 value.

Two additional output signals are derived from the interface circuit and are provided for use by EUI. The first signal is the EUI Calibration Command and a complete description will be found in the next section (3.1.2.3.5.3). The second signal is a clock signal that is 16-times the baud rate of the EUI serial data channel. This is provided so that a stable oscillator need not be constructed in the EUI for the purposes of driving the data recovery circuits. Both of these signals have series resistance protection which will limit their drive capability and rise times, dependent upon the EUI's circuit loading.

The serial data channel is optically isolated and floating from all circuit grounds to eliminate ground loops. It expects a current as an input. A 510 ohm series resistance (R4) is provided to protect the input diode from excessive currents. A positive current into the input of at least 0.5 milliamperes will be interpreted as a logic zero (0) at the processor's interface circuit. A positive current of less than 0.02 milliamperes will be interpreted as a logic one (1). In accordance with the serial communications protocol, the normal, idle, state of this input channel is the logic one state with zero input current.

The return line for the input signal is floating with respect to the circuitry in the PMS. Therefore, the EUI may drive either the input line with positive current or sink a negative current out of the return line. The voltage at the input signal line should not exceed 5 volts, either positive or negative, with respect to the return line. The input signal line and its return may have a common mode voltage up to 100 volts with repect to the chassis ground.

An example EUI interface is given in Figure 3.1.2.3-1. Component values may need to be adjusted to suit data rate requirements and other circuit details. Note that, if power is taken from the supply leads of the EUI interface of the PMS (J6), the maximum current from either supply should be limited to 250 milliamperes by either a fuse or other current limiting device. If currents exceed this limit, the protection fuses internal to the PMS will open and no power will be available to the EUI. The PMS EUI protection fuses are soldered onto the Motherboard and are not field replaceable.

SRI International
Menlo Park, California 94025

FSCM NO. 03652		
PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	
DATE	7/15/85	REV. G
SHEET NO.	31 of 73	
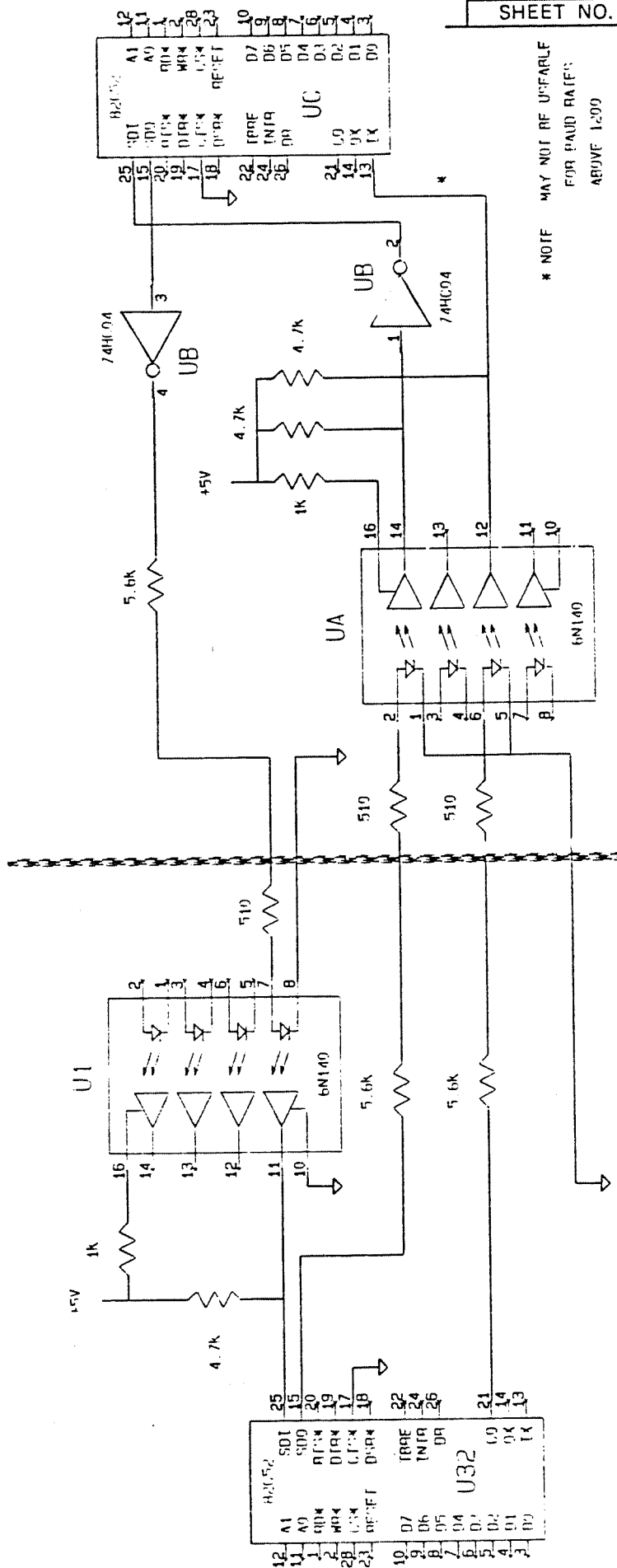
ORIGINAL PAGE IS
OF POOR QUALITY

Figure 3.1.2.3-1 Example EUI Interface

If a data rate in excess of 1200 baud is desired for the serial input channel, some simple modification to the Processor Board will allow the input circuit time constants to pass data to 9600 baud. This modification involves changing the value of a resistor that provides a back-bias to the photo detectors in the opto-isolator.

Resistor R9 on the DCU Processor Board (PMSF-DC-PR00) should be decreased in value from 4.7K ohms to 1K ohms. This lower value will decrease the time delay in the opto-isolator due to stored charge when illumination from the photoemitter is halted (i.e., no current flows at the input to the opto-isolator).

Resistor R9 is included for protection of the HP 6N140 (U1) opto-isolator from damage due to damage from static discharges with dv/dt exceeding 50,000 Volts/microsecond. The higher value of R9 used in the initial construction is attributable to the efficient use of parts in component packages in the prototype that are not utilized in the flight models. The lower value of R9 (1K ohm) is quite adequate for static discharge protection since the inputs have series resistence and the operational procedures for mating to the EUI connector will minimize the possibility of excess static discharges.

3.1.2.3.5.3 Calibration Sequences

Digital lines output from the PMS through the EUI connector are provided for calibration timing control in the EUI, as shown in the timing diagram of Figure 3.1.2.3-2. Whenever a calibration is chosen by the operator, the "Digital Data Out Control" line is raised to signal that a calibration sequence is in process. The line stays high until the calibration process is over. During the time that this line is high, the EUI may look at the "Calibrate Signal Out" line. This second line is raised and lowered according to a prespecified timing pattern, with a duty cycle and period that are preprogrammed in the Parameter PROM. A separate duty cycle and period may be selected for each experiment.

Digital Data Out Control _____⌐‾‾‾‾‾‾‾‾‾‾‾‾⌐_____

Calibrate Signal Out ____⌐‾⌐_⌐‾⌐_⌐‾⌐_⌐‾⌐_⌐‾⌐_⌐‾⌐__

Figure 3.1.2.3-2 Calibration Sequences

3.1.2.3.6 CDTR Digital Data Interface

The PMS has the capability of sending a digital serial stream of data to one channel of the CDTR model 3. Any of the data types described in the data format specifications which are available to the Control Processor may be multiplexed and transmitted to the CDTR through this serial link. Each record follows the data format specifications.

Because of the nature of very densely recording bits on the CDTR, errors may occur in the recording. To minimize the effect of these possible errors, all particularly important PMS data records, such as blood pressure, are sent redundantly to the CDTR, with an exact copy of a record immediately following it.

3.1.2.3.6.1 Data Stream Format

Each byte of data transferred from the PMS to the CDTR becomes a word of data in the CDTR. A CDTR data word from the PMS consists of 10 bits. The eight most significant bits contain the byte of data from the PMS. The two least significant bits are used to indicate the validity of the upper eight bits. When both bits are 1, the upper eight bits are valid; when they both are 0, the upper eight bits are not valid. No other combination should exist.

For example, the bit stream 1100110011 represents the byte of data 11001100, or 0CC in hexadecimal, and 0000000011 represents 0. The bit streams 1100110000 and 00000000 do not contain valid data.

Generally, PMS digital data will be available for recording on the CDTR only on a sporadic basis. Since the CDTR must record something for every one of its sample times, much of the data recorded by the CDTR from its digital channel will be invalid. Therefore, it is extremely important to search for the validity bits, which will only be present when the PMS has transmitted valid data.

3.1.2.3.6.2 Interaction with CDTR

The CDTR Digital Data Interface is comprised of a serial data output whose bits are shifted by a clock supplied from the CDTR (Cassette Data Tape Recorder). An additional digital input from the CDTR provides framing synchronization to the shifted bits so that they can represent data words. Each output word is 10 bits in length. The most significant 8 bits are loaded by the Control Processor in one output instruction; the two remaining bits are loaded by a second output instruction. The data timing is defined in SRI Specification CDTR-30-0000-TS and is indicated conceptually in Figure 3.1.2.3-3. Timing values should be obtained from the referenced specification. This PMS interface is compatible with the three recorder speeds contained within the specification (i.e., 3/16, 3/8, and 3/4 inches/second).
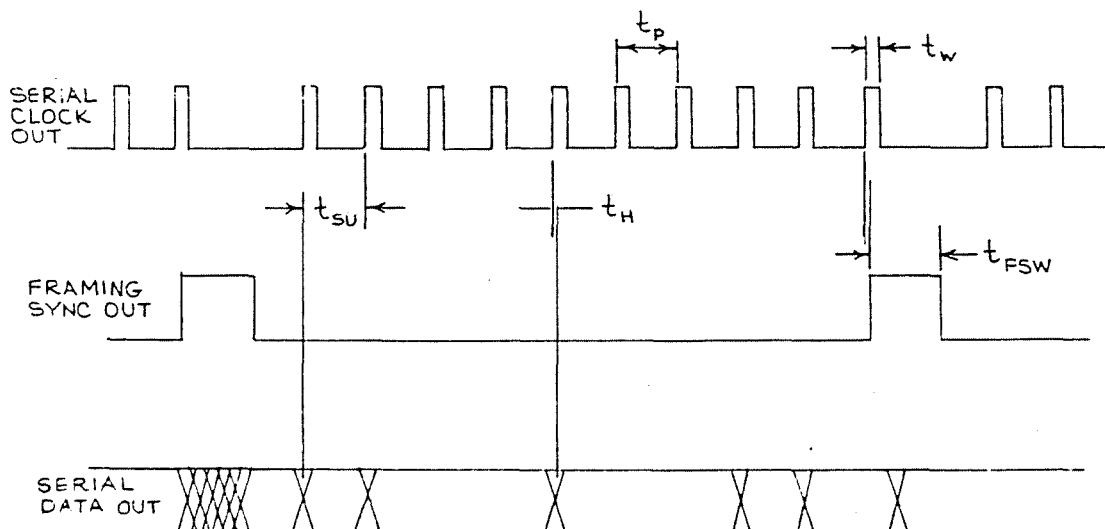

Figure 3.1.2.3-3 CDTR Digital Channel Timing

Data inputs and output are at CMOS logic levels compatible with the 5 Volt logic supply. Serial output data is presented with positive logic levels (i.e., 0 = 0 Volts, 1 = +5 Volts) with the most significant bit being available at the interface at or before the rising edge of the clock signal from the CDTR. The interface circuits are directly coupled between the PMS and the CDTR without isolation circuits because the CDTR is an isolated system that does not have paths to the spacecraft frame that could contribute to ground loop problems.

As bits are shifted through the internal shift register, the least significant bits are set to logic zero. Therefore, reads of more than ten bits will see zeros. If only the most significant byte of the data is written by the processor, the two least significant bits will always be zero following at least one read frame from the CDTR.

3.1.2.3.7 Experiment Parameter Data Base

3.1.2.3.7.1 General Description

   The parameter data base contains data primarily describing the selectable experiments, subjects, and time intervals between cuff inflations. At present one may choose between four experiments, four subjects and eleven time intervals (including user-timed inflations as desired.)

   An experiment is described by the following parameters:

o The experiment name (up to six characters)

o Identification of default subject (up to 10 characters)

o The default time interval between successive cuff inflations (sec.)

o Three numbers specifying a calibration square wave period and square wave high period. They are used in generating calibration timing pulses.

o Data to allow selection of input voltage ranges for each channel +/-2.5 volts or 0-5 volts.

o A value specifying which multiplexor table is to be used in ADC sampling. Each multiplexor table contains an ordered list of the channels to be sampled. The table wraps back to the first channel in the list after accessing the last one in the list. Any number of multiplexor tables may be included in the data base.

o A value specifying a table of devices (e.g., RS-232C, CDTR) that are to receive the experiment and subject names at start-up and after experiment or subject changes.

o A value specifying a table of the types of messages (e.g., blood pressure, type 5) that are to be sent to the RS-232C link.

o A set of tables specifying a scale factor and offset for each possible ADC channel. Also included are values specifying what to do with the data from each channel, e.g., sum with another channel and send to the DAC.

A subject is characterized by the following parameters:

o   Name of subject (up to 10 characters)

o   The maximum time for a cuff deflation (sec.)

o   The upper pressure limit for a cuff inflation (mmHg)

o   The minimum cuff pressure for any deflation (mmHg)

o   The number of K-sounds necessary for a blood pressure measurement

o   The nominal RK slope for this subject (msec/mmHg)

o   Whether to use unfiltered or filtered K-sounds for the DAC output

o   Whether or not to display fourth phase diastolic blood pressure

o   Whether or not to use software valve noise windowing

o   A set of flags is included that prevents/allows the user to change
    each subject parameter above, except subject name. For instance,
    a flag may be set such that the user is allowed to change the
    maximum cuff pressure, but another flag may be in the state which
    prevents the user from changing the nominal RK slope.

o   A default K-sound amplifier gain that can be changed by any user
    is also included.

The preceding lists of experiments and subject parameters
represent values that must be entered at "pre-programming time." The
number of experiments and subjects, both currently four, may be
increased to include any possible set of experiment/subject parameters
not currently available. The set of selectable intervals representing
the times between successive cuff inflations currently goes from 45
seconds to 60 minutes in 10 discrete settings. The user may also
select "manual." This will allow him or her to request cuff inflations
as desired.

The data structure of the parameter program is flexible enough
to easily allow future additions of experiment-relevant data.

3.1.2.3.7.2 Spacelab 4 Parameters

The following paragraphs present a description of the digital data required by each SL4 experiment from the PMS. The information that is displayed on the RCDU is the same for all experiments and is described first. Data that is sent to the RS-232C link follows. Next the DAC output is discussed. Finally, a summary of important experiment, subject and time interval parameters is included.

3.1.2.3.7.2.1 RCDU Data

All four experiments receive the same information and data on the RCDU. This includes:

o Experiment Numbers: choice of E022, E066, E198, E294, TEST

o Subject ID's: choice of MS1, MS2, PS1, PS2, PS3, PLT, CDR, TEST

o Time interval between blood pressure measurements: choice of manual or 45 seconds to 60 minutes in 10 discrete steps.

o Heart rate: A 4-beat average in beats/minute. A display of "0 bpm" means no ECG has been sensed for the past 6 seconds.

o Cuff calibration data: primary and reference cuff transducer values at two pressures. The primary data is preceded by "P=" and the reference data by "R=". The reference data represents four times the actual pressure in mmHg. The primary values are calibrated against the reference values.

FSCM NO. 03652		
PROJ. NO. 5348		
SPEC. NO. PMSF-20-0000-SP		
DATE 7/15/85		REV. G
SHEET NO. 38 of 73		

SRI International
Menlo Park, California 94025

o Blood pressure measurement results: one of the following is displayed as the result of requesting a blood pressure measurement.

a) The computed blood pressure, displayed as systolic pressure over diastolic pressure in mmHg, and fourth phase diastolic if that option has been chosen

b) The message, "ERROR x," if the data processor algorithms conclude that the data acquired during a blood pressure measurement is not adequate for an accurate calculation of the systolic and/or diastolic pressure. The error codes (x) follow:

o 1 - Too few K-sounds were detected.

o 2 - The pulse pressure (systolic minus diastolic) was too small (<5 mmHg).

o 3 - The computed RK slope was negative.

o 4 - The algorithms threw out too many possible K-sounds, so not enough were left.

o 5 - In a test deflation (subject=TEST) the cuff pressures were not reasonable values.

o 6 - In a test deflation (subject=TEST) the RK intervals were not reasonable values.

c) The message, "ABORTED," followed by a message giving the reason the blood pressure measurement was stopped. These messages are:

o "MANUAL" - The operator requested that the measurement stop.

o "OP/OT" - an overpressure or overtime condition has occurred.

o "NO ECG" - the ECG signal has been lost

o "INFL OT" - the time to inflate the cuff was excessive

o "NO REF" - the cuff's pressure transducer reference voltage was lost

3.1.2.3.7.2.2 RS-232C Link

All experiments receive information and data via the
RS-232C link. The following list descibes what is sent to the
link. The data format type is in parentheses:

1) Power-on indication (0)
2) Experiment and subject names (1)
3) Experiment parameters (2)
4) A four beat average of the heart rate (3)
5) The calibrated scale factor and offset values for the primary cuff transducer (4)
6) Blood pressure data, including systolic pressure, diastolic pressure, fourth phase diastolic pressure, and error code (5)
7) An abort indicator, plus reason, as appropriate (6)
8) Cuff pressure transducer data, twice during a calibration, with the first or higher value flagged (10)
9) Cuff pressure, at each beat during a deflation (11)
10) Battery low indication (13)
11) Current Korotkov sound gain setting (14)

A description of the content and format of the above list is
found in the General Data Format Section 3.1.2.3.1.

3.1.2.3.7.2.3 DAC Output

All experiments may currently use the output of the
digital-to-analog converter. At present the output is the sum of the
cuff pressure and the filtered (or unfiltered, if selected)
Korotkov-sound amplitude. The output voltage of the DAC is in the 0
to 5 volt range. Sums with magnitude greater than 5 volts or less
than 0 volts are clipped at 5 or 0 volts, respectively.

3.1.2.3.7.2.4 Experiment, Subject, and Time-Interval Parameters

All experiments have the same default subject, MS1, and a
default time interval between cuff inflations of "manual," i.e., blood
pressure is only taken when requested. Additionally all experiments
offset input channels 1 and 2 (ECG and K-sounds) by 2.5 volts, i.e.,
bipolar inputs of +/-2.5 volts are expected on these channels. In all
experiments but TEST the other six channels are expected to be
unipolar inputs in the 0 to 5 volt range. The TEST experiment expects
channels 5 and 6 to be bipolar inputs.

In specifying a subject ID, one is selecting a set of
parameters which are described in section 3.1.2.3.1. The parameters
currently are the same for each subject, but they can be defined
specifically for each subject. All of the parameters except for subject
name are in a "default parameter" table, which can be changed by the user
via the RCDU, unless a flag for any particular parameter prevents the user
from changing it (see section 3.1.2.3.7.1).

FSCM NO. 03652	
PROJ. NO. 5348	
SPEC. NO. PMSF-20-0000-SP	
DATE 7/15/85	REV. G
SHEET NO. 40 of 73	

SRI International
Menlo Park, California 94025

The following time intervals between cuff inflations are available:

1) Manual (user selects inflations as desired)
2) 45 seconds
3) 1 minute
4) 2 minutes
5) 3 minutes
6) 4 minutes
7) 5 minutes
8) 10 minutes
9) 15 minutes
10) 30 minutes
11) 60 minutes

3.1.2.3.7.2.5 CDTR Output

All experiments for SL4 will receive the same data in the serial CDTR data stream as is sent through the RS-232C link. This does not need to be the case for other missions. The CDTR and the RS-232C data streams may be selected independently of each other.

3.1.2.4 User Interface

3.1.2.4.1 Controls and Displays - RCDU

The PMS has limited control capability, in order to provide simplicity in the running of experiments. Flexibility has been maintained, however, because of the preprogramming capability provided with the system. The controls are used only to select options which have been preprogrammed before an experiment.

3.1.2.4.1.1 Push Button Controls

All control is performed with five push buttons on the face of the RCDU. The push buttons are along the bottom of the display; from left to right are labelled respectively MODE, INC, DEC, EXEC and VIEW. A picture of the RCDU is in Figure 3.1.2.4-1.
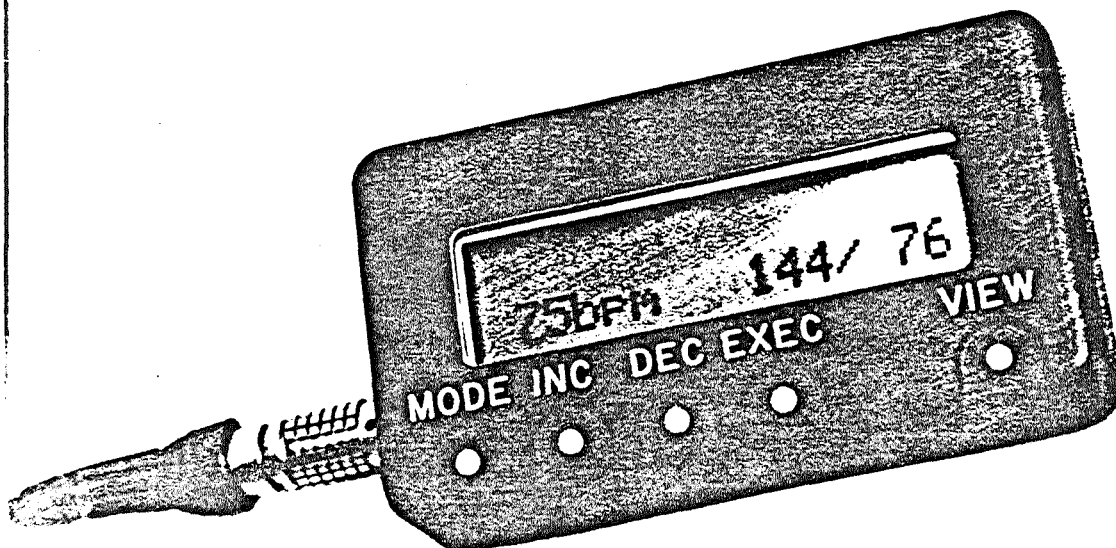

Figure 3.1.2.4-1 The RCDU

MODE

The MODE button is used to switch between various selection modes. When the PMS is turned on, the mode is set to 0. Each time the MODE button is pushed, the mode advances to the next in the sequence. Mode 0 follows in sequence after the last mode. A list of the possible modes follows:

    Mode 0 - Select experiment
    Mode 1 - Select subject
    Mode 2 - Choose to change default parameters or not
    Mode 3 - Select blood pressure measurement interval
    Mode 4 - Select Korotkov sound gain
    Mode 5 - Choose to calibrate or not
    Mode 6 - Execute experiment
    Mode 7 - Choose to change deflation bleed option or not

To stop the running of one experiment and to choose another experiment, the MODE button can be pushed at any time during Mode 7. A new experiment may then be defined in Mode 0. If the experiment is not changed (this is accomplished by pushing the MODE button again, thus entering Mode 1 without having pushed any other buttons), the running of the current experiment is not disrupted. Data will continue to flow through the system, although any data display will be blocked.

Whenever the MODE button is pushed to enter the next mode before any other button has been pushed, the experiment will not be disrupted. In this way it is possible to review previous parameter selections without disrupting the flow of data during an experiment.

INC

The INC button is used in the selection of parameters within any one mode. When the mode is selected, a "default" value for a parameter is chosen and displayed. This has been chosen as default at preprogramming time. Pushing the INC button causes the next possible value for the parameter (defined during preprogramming as next in the table of possible values) to be chosen and displayed. Subsequent pushes of INC cause the following value in the table to be selected. The value selected after the last one in the table is the first one in the table.

The INC button is a repeating switch. Holding it down continuously causes repeated selection and display of the consecutive values, at a rate of about once a second.

DEC

The DEC button is used exactly as the INC button, except that the previous value in the table is selected. The value selected after the first one in the table is the last one in the table. The DEC button is also a repeating switch.

EXEC

The EXEC button is used to select special processes. Its meaning varies, depending on the current mode. In Mode 2 (defaults) pushing the EXEC button causes the default parameters to be displayed for possible change. In Mode 5 (calibrate) pushing the EXEC button causes the calibration sequence to take place. In Mode 6 (execute) pushing the EXEC button causes the "state" of blood pressure measurement to change. If a blood pressure measurement is in process, it is aborted. Otherwise, a measurement is started. In Mode 7 (bleed select) pushing the EXEC button switches between automatic and continuous bleed. During other modes the button is ignored.

VIEW

The VIEW button is used to change the viewing angle of the display. The viewing angle for the liquid crystal display is very narrow. The button makes it possible to see the display from various angles by causing an adjustment with each push. In response to consecutive pushes on the button, the display is changed through eight possible viewing angles and then starts over with the first angle.

3.1.2.4.1.2 Displays

The RCDU contains a 2-line liquid crystal display (LCD), with 16 characters in each line. All the PMS displays are output to the LCD. The current possible display formats are described below. Specialized displays are easy to develop in support of specific experiment needs.

LOW POWER

This display can occur at any time in the upper left corner of the display. The format is "LOW DC". If this display appears the battery should be changed as soon as possible. The display may disappear if another display is written over it, but it will reappear if the low power condition continues.

EXPERIMENT CHOICE

This display has the format of "EXP=AAAAAA", where the AAAAAA field represents the current experiment identification. Pushing INC or DEC will change this field to a different experiment identification.

SUBJECT CHOICE

This display has the format of "SUBJ=AAAAAAAAAA", where the AAAAAAAAAA field represents the current subject identification. Pushing INC or DEC will change this field to a different subject identification.

CHANGE DEFAULTS

The format of this display is "CHANGE DEFAULTS? / YES=EXEC".
Pushing the MODE button switches to the next mode without displaying
or changing any default parameters.

If the EXEC button is pushed, the default value for the first
of the parameters in the Default Parameter Table is displayed.
Pushing the MODE button causes the default value for the next
parameter in the table to be displayed. If it is permissible to
change a parameter, it may be changed by the use of the INC and DEC
buttons as described above. After the last default parameter has been
displayed, pushing the MODE button switches to the next mode.

Section 3.1.2.3.7.1 describes the default parameter
specification process in more detail.

BLOOD PRESSURE MEASUREMENT INTERVAL CHOICE

The format of this display is "BP INT=DDDDDD", where the data
field DDDDDD may either be minutes and seconds specified as MM:SS, or
the word MANUAL. The MM field represents the current number of
minutes, and the SS field represents the current number of seconds
between automatic blood pressure cuff inflations. Currently the
Parameter PROM is programmed for selection between 10 time intervals:
45 seconds, and 1, 2, 3, 4, 5, 10, 15, 30, and 60 minutes.

Blood pressure measurement only on demand is also a possible
selection, in which case the MM:SS field is replaced by MANUAL. If
the manual condition is selected, a cuff inflation will not be started
automatically.

Pushing the EXEC button will cause an inflation at any time the
cuff is not already inflated. This is true even if a time interval for
automatic inflation has been chosen.

Pushing INC or DEC will rotate the time interval field
between the eleven possible selections.

GAIN SELECTION

The format of this display is "GAIN=x". It is possible to
choose between four different gain settings for the Korotkov sound
microphone amplifier by using the INC and DEC buttons as described
above. The settings are numbered 1, 2, 3 and 4, with 1 representing
the lowest gain and 4 representing the highest gain. Gain level
should be selected with care once the microphone has been placed. It
may be necessary to change the gain to a lower setting when a subject
is exercising than when the subject is at rest.

HEART RATE

The format of this display is "DDDbpm" in the lower left
corner of the display. This field represents heart rate in beats per
minute, where DDD is the current heart rate, averaged over four heart
beats.

CALIBRATION CHOICE

The format of this display is "CAL? YES=EXEC". Pushing the EXEC button causes a calibration sequence to begin. Pushing the MODE button switches to the next mode without a calibration sequence. The INC and DEC buttons are ignored. The heart rate display also appears with this display.

A calibration sequence consists of two operations conducted in parallel. A calibration timing pulse is sent to the EUI, along with a line which is held high during the entire calibration period. The duty cycle and frequency of the calibration pulse are preprogrammed parameters for the particular experiment.

The primary cuff pressure transducer in the subject harness is calibrated against the reference transducer during the calibration sequence. This is necessary because the primary transducer cannot be pre-calibrated exactly. Such calibration is dependent on the interconnection with a particular subject harness.

During this calibration the cuff is inflated to a plateau near the upper end of normal operating range (around 200 mmHg). After a few seconds it is deflated to a plateau near the lower end of normal operating range (around 50 mmHg). After a few seconds it is deflated and the numbers acquired through the Analog-to-Digital converters are used in calculating the appropriate scale factor and offset.

Pushing either the MODE or the EXEC button will cause the calibration sequence to stop. If the blood pressure calibration is in process with the cuff still inflated when the EXEC button is pushed, the cuff calibration will be aborted and the cuff immediately deflated.

CALIBRATION

The format of this display is "CAL... P=DDDD / R=DDDD". The CAL... field on the top line indicates that calibrations are being performed. The P=DDDD field represents the value read from the Analog-to-Digital converter in the Data Processor for the primary cuff pressure transducer. The R=DDDD field represents the value read for the reference transducer. The heart rate display also appears in the lower left corner.

The P and R displays are primarily of diagnostic value, as an indication that the transducers are correctly set up. The value for the reference transducer represents mmHg times 4 during each of the two plateaus of the calibration cycle. The corresponding primary transducer values should be no more than twice nor less than half of the reference transducer values.

BLOOD PRESSURE DEFLATION

"PRES=DDD" appears in the bottom right corner of the display and represents the cuff pressure at each step during a blood pressure deflation. Heart rate is displayed in the bottom left corner. The pressure display is primarily for diagnostic purposes, to verify that the cuff is deflating properly. Also, if the headphone amplifier or an independent source of audible Korotkov sounds is used, it can be used to judge the accuracy of the final blood pressure value.

BLOOD PRESSURE

This display appears at the conclusion of a successful blood
pressure measurement in the lower right corner. DDD/DDD represents
systolic/diastolic blood pressures, and heart rate is still displayed.

BLOOD PRESSURE ABORTED

The format of this display is "ABORTED / AAAAAAA" on the right
side of the display. It occurs instead of the blood pressure display
if a blood pressure measurement has been aborted. The AAAAAAA field
gives the reason for the abort. Reasons may include the following:

NO ECG   - the ECG signal has been lost, and the cuff can't be
           deflated correctly without it.

OP/OT   - the BPM hardware has detected an overpressure or an
           overtime condition.

INFL OT - too much time was taken during cuff inflation, possibly
           because a valve is stuck open or there is not enough power
           to correctly operate the pump.

NO REF   - the reference voltage for one or both of the cuff
           pressure transducers has been lost, making it impossible
           for the Data Processor to read the transducer output.

MANUAL   - the operator requested an abort by pushing the EXEC
           button.

BLOOD PRESSURE ERROR

This display has the format "ERROR x". It appears in place of
the blood pressure display after a deflation when it is impossible to
determine the blood pressure from the data collected. The possible
errors are listed below:

ERROR 1 - too few Korotkov sounds were detected

ERROR 2 - the pulse pressure (systolic minus diastolic) was
          below the minimum value

ERROR 3 - the RK slope was negative (impossible with good data)

ERROR 4 - enough Korotkov sounds were detected, but too many
          were not acceptable

ERROR 5 - bad cuff pressure data during test mode (SUBJ=TEST)

ERROR 6 - bad RK intervals during test mode (SUBJ=TEST)

CONTINUOUS OR AUTOMATIC BLEED SELECTION

If the MODE button is pushed while in the execute mode (mode 6) the user is allowed to choose between the two possible deflation options: automatic or continuous bleed. Section 3.1.2.4.4 explains the difference between these two options. The current option chosen is indicated during execute mode by an "A" (for automatic) or a "C" (for continuous) on the upper right side of the display.

When the bleed selection mode is entered either "CONT. BLEED? / YES=EXEC" (if the current option is automatic) or "AUTO BLEED? / YES=EXEC" (if the current option is continuous) is displayed. Pushing the EXEC button switches the option and returns the mode to execute. Pushing the MODE button changes back to Mode 0.

3.1.2.4.2 On-Off Switch

The On-Off switch on the Connector End Plate is used to turn the battery power on or off. It is not used to turn on power to the PMS when the PMS is connected to rack power. A switch on the rack interface panel should be used to turn the PMS on in this case. When the PMS is connected to rack power, the On-Off switch always should be in the Off position, to conserve battery power.

3.1.2.4.3 Headphone Jack

The headphone jack was included to enable the user to hear the Korotkov sound signal generated by the microphone. However, the headphone amplifier is not operative at this time.

3.1.2.4.4 Manual Valve in Subject Harness

The PMS is capable of enabling a manual valve in the Subject Harness instead of the solenoid bleed valve in the PMS pneumatic circuitry. The PMS normally controls the rate of cuff deflation by turning the bleed valve on and off once per heart beat. This is the "automatic bleed" option. Alternatively, the user may choose the "continuous bleed" option. This enables the user to control the cuff deflation rate manually instead of having the PMS do it automatically. Then when a blood pressure measurement is taken, the cuff still will be inflated automatically. After the inflation the bleed valve will be held closed and another solenoid valve will be opened which allows the deflation to be controlled by the manual valve in the harness.

3.1.2.4.5 Alarm Capability

As currently programmed, the PMS has no alarm capability. Visual alarms would be easy to implement, however, using the RCDU to produce various effects. For instance, a blinking cursor or a blinking portion of the display may be used. Programs may be written to detect alarm conditions such as a signal exceeding limits, and a visual alarm may be caused. Alarm information may be passed over the digital link from the EUI, which may cause a visual alarm display. Conversely, alarm information may be generated and passed over the digital link to the EUI.

3.1.3 Major Component List

The major components are listed in tree form in the PMS drawing trees. Refer to PMSF-20-0000-DT, PMSF-CD-0000-DT, and PMSF-DC-0000-DT.

3.1.4 Customer Furnished Property List

Government Furnished Equipment built into the PMS includes the ECG amplifiers and all the bulkhead connectors, all wire, the Velcro on the RCDU's, and the Goretex for the battery pouch.

In addition, NASA built the subject harness and all the external cables (except for the cable from the DCU to the RCDU).

3.2 Characteristics

3.2.1 Performance

See End Item Specification.

3.2.2 Physical

The DCU measures 6.5" x 10.15" x 3.13" and weighs 2.7 kg.

The RCDU measures 3.5" x 2.0" x 1.0" and weighs 126 g.

The battery pack measures 1.47" x 3.75" x 3.90" and weighs 302 g unloaded. Zinc-air battery cells gain weight as they are exposed to air, so a precise weight cannot be given. A loaded battery pack weighs around 800 g.

3.3 Design and Construction

All design and construction was to JSC 8080 standards. The workmanship was performed according to NHB5300.4(3A-1).

3.4 Major Component Characteristics

3.4.1 DCU Package

The DCU Package is constructed of aluminum in a clamshell fashion. The battery cover side is held on with three quarter-turn fasteners and is easily removeable without the use of tools, to provide for easy installation of a battery pack. The card cover side has an end plate at each end, which is attached by screws. The end plates contain all the bulkhead connectors. The card cover may be easily removed for trouble shooting by removing the screws securing it to the chassis. The chassis, battery pack, and associated pneumatics and wiring fit inside the package.

SRI International
Menlo Park, California 94025

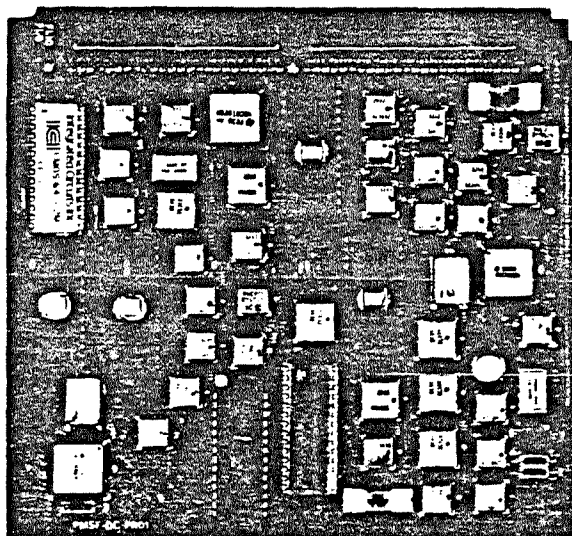| FSCM NO. 03652		
PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	
DATE	7/15/85	REV. G
SHEET NO.	49 of 73	

3.4.2   DCU Chassis

3.4.2.1   Processor Board

The following is a description of the functions of the
Processor Board.   Refer to the schematic diagrams in drawing
PMSF-DC-PR00-SC for circuit details.   Figure 3.4.2.1-1 is a picture
of the board.

Figure 3.4.2.1-1   Processor Board

The Processor Board contains two microcomputer systems: the
Control Processor and the Data Processor.   The Control Processor
controls the order and execution of experiments and the flow of data
into, out of, and within the PMS.   The Data Processor is dedicated to
performing preprogrammed computations under the control of the Control
Processor.   For SLS-1, the Data Processor is dedicated to the
computation of heart rate and blood pressure and is responsible for
the inflation and deflation of the blood pressure cuff.   The two
systems communicate with each other over a full duplex, asynchronous
serial data link.   The Control Processor comprises the circuitry
largely to the right of the center of the board; the Data Processor
circuitry is to the left.   Because of the digital nature of the
circuitry, there are no adjustments that are required for proper
circuit operation.

The systems are similar to each other in their architecture.
They are constructed from CMOS components and differ, primarily, in
the number and type of peripheral circuits.   Each 8-bit CPU is a
National Semiconductor NSC800-4 operating with a crystal oscillator
frequency of 4.9152 MHz yielding an internal T-state period of 406.9
nanoseconds.   A single register to accumulator add instruction is
executed in 1.63 microseconds.   The system implements a classical Von
Neuman architecture with 65,536 memory addresses and 256 I/O addresses.

Each processor may be sent into a Power Save mode to reduce power dissipation during periods when computational activity is not required. When in this mode, the internal clock of the CPU is stopped, suspending CPU operation and halting accesses to other system components. The oscillator continues to run to provide a signal source for communications and timing peripherals which have the ability to cause the processor to exit this mode.

The Power Save mode is entered whenever a write operation is directed to I/O port 70H, regardless of the data value written. The mode will be exited upon the receipt of any interrupt that is enabled by the processor's interrupt controller or by the execution of a system reset, as would occur at power-on or by manual intervention during board testing.

Each processor derives its operating instructions from UV-erasable, programmable read-only memory (EPROM). Two Hitachi HN27C64G-25 EPROMs of 8,192 bytes each respond to memory addresses from 0000H to 3FFFH. Read/write memory is provided by an ICI 64-02M(ES) hybrid circuit consisting of four Hitachi 6116 RAM chips and a 74C138 decoder. It is electrically and pin-compatible with a Toshiba TC-5565 monolythic RAM. The read/write memory is addressable in the range from 8000H to 9FFFH.

Because each processor must perform a different function, the peripherals that complement each processor vary between systems. The Control Processor has four asynchronous communications chips, a dual timer and a serial output interface to the CDTR. The Data Processor requires only a single serial communications interface and possesses a combined timer and programmable I/O interface chip. The individual functions of each processor will be addressed in the following sections.

3.4.2.1.1 Control Processor

3.4.2.1.1.1 Interrupts

The Restart and Non-Maskable Interrupts of the NSC800 CPU are not utilized. Instead, a Harris 82C59A Programmable Interrupt Controller (PIC) is utilized to mask and prioritize the eight interrupt input channels of the PIC. The output of the PIC drives the Multi-Mode Interrupt (INTR*) input of the CPU. The CPU is programmed to operate in its 8080-compatible Mode 0 interrupt mode. The PIC returns a CALL instruction to the CPU when the CPU acknowledges an interrupt. The CALL instruction acts as a vector to one of eight interrupt service routines. A table of interrupt sources for the Control Processor is given below:

Interrupt Level	Interrupt Source
0 (Highest)	A/D Conversion Complete
1	Timer Event
2	Interprocessor UART
3	RS-232C Interface UART
4	CDTR Word Frame
5	EUI UART
6	RCDU UART

3.4.2.1.1.2 I/O Addresses

The addresses which are decoded by the Control Processor to access its peripherals are presented in the following table:

```
                    I/O ADDRESSES - Control Processor
                    --------------------------------

         M                L
         s - - - - - - s
         b                b
         ---              ---


         0 0 0 X X X A A      EUI UART - Harris 82C52
         0 0 1 X X X X A      Interrupt Controller - Harris 82C59A
         0 1 0 0 X X X A      CDTR Data Register - 10-bit, Left-justified
                                        A = 1   MSB
                                        A = 0   LSB
                                        Zeros are output after 10 bits.
                                        Write-only
         0 1 0 1 X X A A      Not used - write only
         0 1 1 0 X X X X      Not used - write only
         0 1 1 1 X X X X      Power Save Mode Command - write only
         1 1 0 0 A A A R      RCDM UART -           Harris 82C52
         1 1 0 1 X X A A      Interprocessor UART -        "
         1 1 1 0 X X A A      RS-232C Interface UART       "
         1 1 1 1 X X A A      Control Proc. Dual Timer - RCA CDP1878
         1 0 0 0 X 1 X 0      A/D Converter - NSC ADC1001
                                        10-bit, Left-justified, 0-5 Volt
                                        First read:      MSB
                                        Second read:     LSB w/zero fill
                                        Read-only device
         1 0 0 1 X 1 X A      D/A Converter - NSC DAC1232
                                        12-bit, Left-justified, 0-5 Volt
                                        A = 1   MSB
                                        A = 0   LSB
                                        Write-only device
         1 0 1 0 X 1 X X      Multiplexor Channel
                                        3-bit, Right-justified
                                        Data = XXXXX000 = Channel 1
                                             = XXXXX111 = Channel 8
                                        Write-only device
         1 0 1 1 X 1 X X      Input Offset Configuration
                                        1 bit per channel
                                        Lsb of Data Byte = Channel 1
                                        Msb of Data Byte = Channel 8
                                        Data bit = 0 sets 0-5 Volt input
                                        Data bit = 1 sets +/- 2.5 Volt input
                                        Write-only device
         1 0 1 1 1 0 1 1      NSC800 Interrupt Control Register
                                        See CPU manual for description


                    A = Address bit
                    R = Read/Write* bit       R must = 1 for a read operation
                                                   = 0 for a write operation
                    X = Don't care bit
```

3.4.2.1.2 Data Processor

3.4.2.1.2.1 Interrupts

The Data Processor utilizes the same interrupt circuitry as described for
the Control processor. A table of interrupt sources for the Data Processor
is given below:

Interrupt Level	Interrupt Source
0 (Highest)	A/D Conversion Complete
1	NSC810 Timer 1 Event
2	Interprocessor UART
3	K-Peak
4	R-Peak
5	Reference Loss
6	Over Pressure/Over Time Alarm
7	NSC810 Timer 0 Event

		FSCM NO. 03652	
(SRI logo)	SRI International Menlo Park, California 94025	PROJ. NO. 5348	
		SPEC. NO. PMSF-20-0000-SP	
		DATE 7-15-85	REV. G
		SHEET NO. 53 of 73	

3.4.2.1.2.2   I/O Addresses

The addresses which are decoded by the Data Processor to access its peripherals are presented in the following table:

I/O ADDRESSES - Data Processor

```
M                 L
s - - - - - - s
b                 b
---             ---


0 0 0 A A A A A     I/O Ports & Timer - NSC810
0 0 1 X X X X A     Interrupt Controller - Harris 82C59A
0 1 0 X X X X X     Not used - write only
0 1 1 0 X X X X     Not used - write only
0 1 1 1 X X X X     Power Save Mode Command - write only
1 1 X X X X A A     Interprocessor UART - Harris 82C52
1 0 0 0 X 1 X 0     A/D Converter - NSC ADC1001
                            10-bit, Left-justified, 0-5 Volt
                            First read:     MSB
                            Second read:    LSB w/zero fill
                            Read-only device
1 0 0 1 X 1 X A     D/A Converter - NSC DAC1232
                            12-bit, Left-justified, 0-5 Volt
                            A = 1   MSB
                            A = 0   LSB
                            Write-only device
1 0 1 0 X 1 X X     Multiplexor Channel
                            3-bit, Right-justified
                            Data = XXXXX000 = Channel 1
                                 = XXXXX111 = Channel 8
                            Write-only device
1 0 1 1 X 1 X X     Input Offset Configuration
                            1 bit per channel
                            Lsb of Data Byte = Channel 1
                            Msb of Data Byte = Channel 8
                            Data bit = 0 sets 0-5 Volt input
                            Data bit = 1 sets +/- 2.5 Volt input
                            Write-only device
1 0 1 1 1 0 1 1     NSC800 Interrupt Control Register
                            See manual for description



        A = Address bit
        X = Don't care bit
```

3.4.2.1.2.3 Interface and Timer Circuit

        A National Semiconductor NSC810 RAM-I/O-Timer circuit is used
to provide an interface to the miscellaneous logic circuits of the
system comprising the Data Processor and to provide timing for event
scheduling and measurement. Two 8-bit and one 6-bit programmable I/O
ports are included. The functions that are controlled or represented
by each port are described in the following table:

NSC810 PORT ASSIGNMENTS

PA0 -   Motor On Command | "1" = on or close
PA1 -   Main Bleed Valve Command | "0" = off or open
PA2 -   Auxilliary Bleed Valve Command | "0" = off or closed
PA3 -   BPM Strobe - Positive pulse resets OP/OT logic
                    Should be pulsed every time motor is turned on
PA4 -   K-Sound Gain (LSB)

PA5	PA4	Relative Gain
0	0	~4
0	1	~3
1	0	~2
1	1	~1

PA5 -   K-Sound Gain (MSB)
PA6 -   Not used (Pullup resistor)
PA7 -   Not used (Pullup resistor)

PB0 -   Not used (Pullup resistor)
PB1 -   Not used (Pullup resistor)
PB2 -   Over-Pressure/Over-Time Signal   "1" = OP/OT
PB3 -   Reference Loss Signal   "1" = Loss
PB4 -   Timer Gating Signal - Connected to PC3
PB5 -   Not used (Program as an output)
PB6 -   \   Control of Converter Timing
PB7 -   /

PB7	PB6	
0	0	800 Hz
0	1	1200 Hz
1	0	2400 Hz
1	1	1760 Hz

PC0 -   Not used (Program as an output)
PC1 -   Not used (Pullup resistor)
PC2 -   Not used (Pullup resistor)
PC3 -   Timer Gate Input from PB4
PC4 -   Input clock to Timer 1 (see PB6 & PB7)
PC5 -   Output of Timer 1 to Interrupt Controller

Note:

    Any ports labeled "pullup resistor" may be programmed as
    either an input or an output. The input condition is
    slightly preferred. If programmed as an output, a logic 1
    state will cause the least current to be drawn from the
    power supply.

    Any port labeled "program as an output" should be set to the
    output mode as quickly as possible after a system reset to
    prevent excess current drain in the device due to a floating
    input. It may be programmed either high or low.

3.4.2.1.3 Processor Emulation

        Troubleshooting of a Processor is usually done through
emulation of the CPU element. The CPU is removed from its socket and
a special emulator pod is inserted in its place. With this emulator,
internal CPU states can be observed, program breakpoints can be
inserted, and programs can be run in memory in the emulator rather
than on the board. Since the Processor Board is constructed with
surface mount technology to achieve a small size, the CPU of each of
the Control and Data Processors is physically soldered to the board
and its removal is impractical. To overcome this shortcoming, special
logic and an emulator connector are provided in each Processor system.
When emulation is desired, an adapter circuit is plugged into the
emulator connector of the appropriate processor. The CPU emulation
pod is plugged into the adapter. By placing the on-board CPU into a
bus request mode, we are able to make it invisible in the circuit and
the emulator pod becomes the apparent CPU for the system. The
schematic diagram of a suitable adapter circuit is given in Figure
3.4.2.1-2. The signals on the emulator connectors are given in the
following table:

                Control Processor Emulator Connector (J302)

Pin	Signal	Pin	Signal
1	CVPP	2	CDBUS0
3	CBREQ*	4	CPGM*
5	CRD*	6	CWR*
7	CPS*	8	CRESET
9	CRESET OUT	10	CPS*
11	CALE	12	CALE
13	CIO/M*	14	
15	CBAD1	16	CBAD0
17	CBAD3	18	CBAD2
19	CBAD5	20	CBAD4
21	CBAD7	22	CBAD6
23	CBA9	24	CBA8
25	CBA11	26	CBA10
27	CBA13	28	CBA12
29	CBA15	30	CBA14
31	CEINTA*	32	CDBUS1
33	CINTR*	34	CECLK
35	CERSH*	36	CINTR*
37		38	
39	CEALE	40	
41	+5 Volts	42	GND
43	+5 Volts	44	GND

Data Processor Emulator Connector (J303)

Pin	Signal	Pin	Signal
1	DVPP	2	DDBUS0
3	DBREQ*	4	DPGM*
5	DRD*	6	DWR*
7	DPS*	8	DRESET
9	DRESET OUT	10	DPS*
11	DALE	12	DALE
13	DIO/M*	14	
15	DBAD1	16	DBAD0
17	DBAD3	18	DBAD2
19	DBAD5	20	DBAD4
21	DBAD7	22	DBAD6
23	DBA9	24	DBA8
25	DBA11	26	DBA10
27	DBA13	28	DBA12
29	DBA15	30	DBA14
31	DEINTA*	32	DDBUS1
33	DINTR*	34	DEDLK
35	DERSH*	36	DINTR*
37		38	
39	DEALE	40	
41	+5 Volts	42	GND
43	+5 Volts	44	GND

Figure 3.4.2.1-2 PMS Emulator Adapter

PMS
EMULATOR
ADAPTER
23 May 1985

ORIGINAL PAGE IS
OF POOR QUALITY

POWER CONNECTIONS

Ground.

U1-20
U2-10
U3-7
U4-7
U5-7

+5 Volts:

U1-40
U2-20
U3-14
U4-14
U5-14

NORMAL

EMULATE

J1 - To PMS Processor

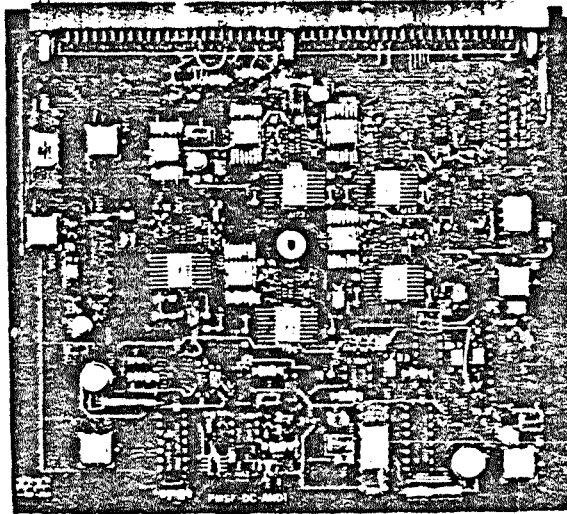| PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	REV. G
DATE	7/15/85	
SHEET NO.	57 of 73	

3.4.2.2 Analog Board

Refer to the schematic diagrams on drawing PMSF-DC-AN00-SC for circuit details on the Analog board. A picture of the board is in Figure 3.4.2.2-1.

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 3.4.2.2-1 Analog Board

3.4.2.2.1 Description

The Analog board contains signal processing circuitry for the control and data processors, the Interface Rack, and the CDTR. The control section contains programmable-offset input buffers for eight channels which can accommodate 0 to +5v or -2.5 to +2.5v input signals and produce 0 to +5V output signals, an eight channel multiplexor and 10-bit A-D converter, a 10-bit D-A converter, and output interface buffers. The data section contains programmable-offset buffers for two channels, and an eight channel multiplexor (the first six inputs are connected to the outputs of the first six control section input buffers) and A-D converter.

3.4.2.2.2 Calibration Adjustments

There are six calibration adjustment pots on the Analog board (R30 is not used). These are set as follows:

1. Adjust R2 for +2.500V @ U4-9.
2. Adjust R18 for -5.000V @ U21-8.
3. With 0 input to the DAC, U21, adjust R9 for 0.00V @ U16-6.
4. Adjust R21 for +2.500V @ U18-4.
5. Adjust R38 for +2.500V @ U29-4.
6. Adjust R46 for +2.500V @ U35-9.

3.4.2.3 Basic Parameters Boards

Refer to the schematic diagrams in drawings PMSF-DC-BP01-SC, PMSF-DC-BP02-SC, and PMSF-DC-BP03-SC for circuit details on the Basic Parameters boards. Figure 3.4.2.3-1 is a picture of the BP01 board with the BP03 board piggybacked on top of it. Figure 3.4.2.3-2 is a picture of the BP02 board.
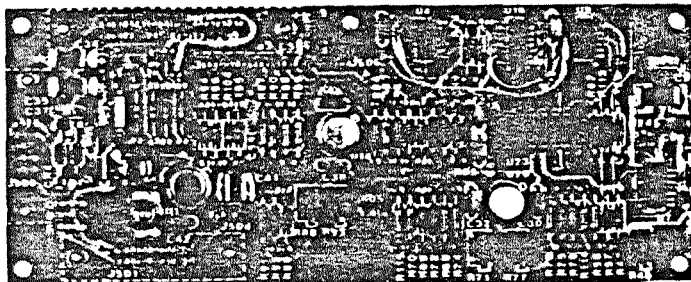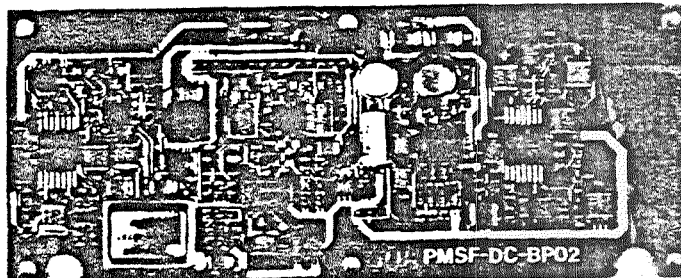
Figure 3.4.2.3-1
BP01 & BP03 Boards

Figure 3.4.2.3-2
BP02 Board

3.4.2.3.1 Description

There are three basic parameters boards, BP01, BP02, and BP03. BP01 contains circuitry for amplifying the outputs of the primary cuff and reference pressure transducers, sensing cuff inflation overpressure and overtime, driving the inflation pump motor and bleed valve, and generating the hold signal for the noise gate sample/hold on BP02. BP03 is mounted on BP01 and contains the auxiliary bleed valve drive circuitry. BP01 contains circuitry for processing the ECG signals from the harness electrodes and the K-sound signals from the cuff microphone. In addition to amplifiers and filters for the signal itself, the ECG channel also includes circuitry for determining the time of occurrence of the R-wave peak. The K-sound channel also includes a programmable gain amplifier, circuitry to determine the time of occurrence of each sound, and a soft limiter to preserve signal amplitude variations while preventing overdriving of following circuitry on the analog board.

3.4.2.3.2 Calibration adjustments

A number of calibration adjustment pots are located on the basic parameter boards. These are:

BP01- 2 pots for the primary cuff pressure transducer amplifier.

2 pots for the reference pressure transducer amplifier.

1 pot for the noise gate hold time.

BP02- 2 pots for the K-sound peak detector.

The following procedures are used to set these pots.

Transducer Calibration - BP01

1. Set up the PMS for operation on the bench, with the harness connected and an inflation bulb and digital pressure gauge plumbed into the air line to the cuff. Remove the PMS cover opposite the battery box and remove the BP02 board.

2. The transducer amplifiers are each calibrated at two points on a straight-line volts/mmHg transfer curve. The points are:

	Reference	Adj.	Cuff	Adj.
	+5.000V @ 255mm	- R93	+2.850V @ 255mm	- R77
	+0.784V @ 40mm	- R88	+0.800V @ 50mm	- R71
Voltmeter connected to	J503-9		J503-13	

The procedure is to connect a digital voltmeter between the specified connector pin and Gnd. and then manually inflate the cuff to the high pressure value and adjust the specified pot for the corresponding voltage reading. The cuff is then deflated to the low pressure value and the second adjustment made. The procedure is then repeated until both voltage readings are correct.

Hold Time Adjustment - BP01

1. The best way to make this adjustment is to trigger U7-4 with an HP10526T Logic Pulser or equivalent and, while monitoring U7-6 with a scope, adjust R46 for a one-shot pulse length of 80 ms.

K-sound Peak Detector Calibration - BP02

1. Reinstall the BP02 board and remove the harness. Monitor the signal at U6-7. It should be a clean +2.5V DC.

2. Measure the voltage at U15-3 with a digital voltmeter and adjust R41 for +2.680V.

3. Measure the voltage at U15-6 and adjust R110 for +2.320V.

These voltages are +2.5V +/- 0.18V. If the voltage at U6-7 is not exactly +2.500V, add or subtract the difference to/from the voltages given in steps 2 and 3.

3.4.2.4 Power Supply Board

Refer to schematic diagrams in drawing PMSF-DC-PS00-SC for circuit details on the Power Supply board. Figure 3.4.2.4-1 is a picture of the board.
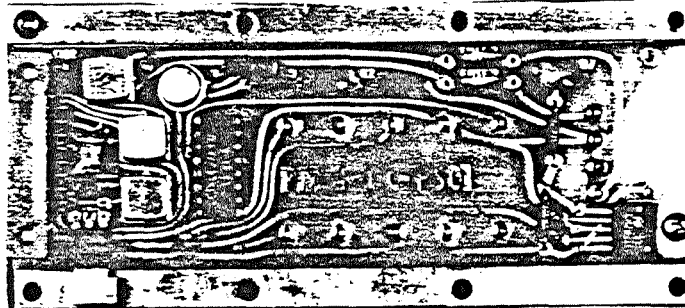
Figure 3.4.2.4-1 Power Supply Board

3.4.2.4.1 Description

The power supply board accepts power from two power source inputs, 28V rack power and internal battery pack power, and generates the +5V, +/- 7V, and +/-unregulated voltage required for operation of the PMS circuitry. When rack power is connected to the PMS, the system always runs, i.e., there is no ON-OFF switch. The 28V drives a high-efficiency DC-DC converter that generates an isolated output of +/- 12V nominal. In the PMS system this output is called +/- UNREG. The + UNREG drives the +5V and +7V regulators, the - UNREG drives the -7V regulator. Both UNREG voltages power the motor and valve drive circuits on the BP01 and BP03 basic parameters boards, and the RS-232 drivers on the PR00 processor board, and are also connected to the EUI connector for external use.

When rack power is disconnected, the three power switching relays operated by the 28V rack power are deenergized. Contacts in these relays disconnect the +/- UNREG lines from the DC-DC converter and connect the battery pack input lines to the battery ON-OFF switch. If this switch is set to ON, the +/- battery input voltages are connected to the +/- UNREG lines. Diodes are used in series with the battery lines to prevent the converter output voltages from being applied to the battery in the event that the battery line contacts should stick closed with the switch ON and rack power applied. The 28V rack power and battery pack input lines are also protected by fuses. One pole of the battery switch and one relay contact are connected in parallel and are used for operation of the CDTR.

3.4.2.4.2 Calibration Adjustments

Two calibration adjustment pots are located on the power supply board. R7 is adjusted for +7.00V at J102-15, and R2 is adjusted for -7.00V at J102-17.

SRI International
Menlo Park, California 94025

FSCM NO. 03652
PROJ. NO.   5348
SPEC. NO.   PMSF-20-0000-SP
DATE   7/15/85   REV. G
SHEET NO.   62 of 73

3.4.2.5 Mother Board

The mother board provides signal connections between boards and connector cables. It contains no integrated circuits. Two fuses for the EUI power are the only components besides connectors on the board.

3.4.2.6 Pneumatic System

3.4.2.6.1 Description

The Pneumatic system inside the DCU consists of a motor and pump, check valve, solenoid valve, pressure transducer (reference), and assorted tubing. The subject harness contains another pressure transducer (primary) and an auxiliary solenoid valve which is driven by circuitry within the DCU.

The primary transducer should be calibrated each time the PMS is turned on or a different subject harness is connected. The reference transducer is used in this calibration (see section 3.1.2.2.5). It also is used as a backup for safety reasons, causing an overpressure shutoff if the primary transducer should fail.

The auxiliary valve controls the flow of air in the system to a manually controlled valve in the harness. If the continuous bleed mode is chosen, the user then may control the bleed rate with the manual valve. The PMS circuitry causes the internal solenoid valve to close and the external solenoid valve to open. In the default automatic mode, the bleed rate is controlled by the data processor causing the internal valve to open and close at appropriate times; the external valve is set to its normal closed position.

When given the "inflate cuff" command, the normally open solenoid valve closes, the pump turns on and inflates the cuff to a predetermined value. In automatic mode the solenoid valve then cycles to deflate the cuff in controlled increments. In continuous mode the deflation is completely controlled by the user. When cuff pressure gets to a predetermined minimum value the solenoid valve remains open, thereby dumping the remaining cuff pressure.

3.4.2.6.2 Leak Detection

If significant size leaks occur, they may prevent the PMS from operating satisfactorily. Small leaks should not prevent satisfactory operation because the processor monitors the rate of deflation and can select a different cycling rate for the solenoid valve to compensate.

If a leak is suspected there are a few easy ways to make tests to determine the cause:

1. Ensure the harness manual bleed valve is closed and use the RCDU to select "continuous bleed". Use the RCDU to cause a cuff inflation and monitor cuff pressure on the RCDU. If it is holding constant, there is no leak in the pneumatics. A leak rate in excess of 2 mm/sec. is unacceptable.

2. With the cuff still inflated, pinch off the air hose right at the quick disconnect. If the leak continues, it is in the PMS. If it stops, it is in the subject harness.

3. If the leak has been determined to be in the PMS, deflate the cuff. There is a possibility the check valve is leaking. This can be checked by rotating the PMS package to another axis of operation (turn it upside down, for example). It may be necessary to do this several times to get the check valve to seat properly. If the leak goes away, the check valve has properly seated.

If the leak is still present, the unit must be referred to a qualified technician for repair. There is no other test that the user can perform.

3.4.3 Battery

3.4.3.1 Description

The battery pack contains 140 individual Gould HP630 zinc-air battery cells. They are stacked 7 cells per stack in 20 stacks, 11 stacks paralleled for V+ and 9 stacks paralleled for V-. It is important that the procedure described below be followed to ensure proper operation of the battery pack after refurbishment. If the cells are not properly cleaned, the pack will not provide sufficient power over its specified lifetime of 60 inflations and 30 hours of operation.

See section 3.1.2.1.4 for more details on the battery pack.

3.4.3.2 Refurbishment Procedure

1. Untie the draw string and remove the battery pack from the pouch.

2. Remove one of the end plates that has air holes by removing the screws, and remove the large printed circuit board (PCB). Care should be taken to prevent compressing or otherwise damaging the bellows on the end plate PCB.

3. Dump all of the batteries out of the stacks. Do not allow the cells to short out to one another. Inspect the cells for any signs of leakage. It is advised to place the cells on 2" wide tape for disposal. Discard in accordance with regulations.

4. Inspect the battery pack for any signs of leakage. If any cells have leaked, remove all the batteries from the other half of the battery pack and clean the battery pack and all PCB's thoroughly with ethyl alcohol. Allow to dry before installing the new batteries.

5. Repeat steps 2 through 4 for the other half of the battery pack.

6. If the batteries did not leak, clean all PCB's and allow them to dry.

7. Inspect the cells on the battery carrier strip as supplied from the manufacturer. Discard any leaking cells as well as those cells immediately next to the ones leaking.

8. The batteries must be cleaned in the following fashion. The necessary tools are Teri brand "teri wipers" or equivalent and a battery cell holder. This cell holder can be made from an empty spool from solder wick that has been cut down the center. The cell can be placed in the center of it while cleaning. NO CLEANING SOLVENTS MAY BE USED ON THE BATTERIES. Cleaning solvents will destroy the cells. Only buffing of the cells must be employed to remove the oxide layer and residual adhesive from the battery carrier. It is imperative that these be completely removed to get the contact resistance to a low enough value for the batteries to operate correctly.

a. Inspect the cell for leakage around the 3 air holes on the "+" side.

b. Place the folded teri wiper on a flat surface, install the battery into the holder "-" side in, and buff the "+" side on the wiper. Being careful not to touch the "+" face, remove the cell, reinstall "-" side out, and buff the "-" side.

c. Again being careful not to touch the cleaned surfaces, place the cell into the battery pack, "+" side out.

d. Repeat for the entire stack.

9. Measure the cell stack voltage. It must be >10.2 VDC. The polarity will depend upon which stack is being measured. Refer to drawing PMSF-DC-3000-SC for location on polarity of test probes.

10. Reassemble PCB, end plate and screws. Note keying pins in battery pack, PCB, and end plate.

11. Repeat steps 8-10 for other side of battery pack.

12. Test battery pack for proper operation using an appropriate battery test box.

13. Place battery pack in pouch and feed the connector through the loop on the side of the pouch. Retie the draw string.

14. Place in a dry, clean air-tight bag.

SRI International
Menlo Park, California 94025

FSCM NO. 03652
PROJ. NO. 5348
SPEC. NO. PMSF-20-0000-SP
DATE 7/15/85
REV. G
SHEET NO. 65 of 73

3.4.4 RCDU

3.4.4.1 General Description

The Remote Control/Display Unit (RCDU) is the primary interface for the user of the PMS. It can be thought of as a detachable terminal connected to the DCU by means of an asynchronous serial line.

The keyboard consists of five momentary contact switches. Some of these may be operated as "hold-down" keys that perform a continuous function as long as they are depressed; others perform a single function regardless of how long the key is depressed. The RCDU software debounces each keyswitch position.

The RCDU also includes an LCD alphanumeric display consisting of two lines of 16 characters each. Each character is formed from a 5 x 7 dot matrix with cursor capability.

As mentioned previously, the RCDU communicates with the DCU via an asynchronous serial line. Thus, the RCDU provides the function of a full-duplex Universal Asynchronous Receiver-Transmitter (UART). The UART performs at 1200 baud. It transfers eight data bits with two stop bits and no parity. There is no requirement for modem control signals in the serial interface.

3.4.4.2 RCDU Data Interface with the DCU

3.4.4.2.1 Keyboard Encoding

Depression of any of four keys results in the transmission of an ASCII code selected from a table. The table contains the following keyswitch assignments:

    - MODE key = ASCII 'A'
    - EXEC key = ASCII 'B'
    - DEC key = ASCII 'C'
    - INC key = ASCII 'D'

A VIEW key also is included on the RCDU. This key controls the viewing angle of the display. It is used internally to the RCDU, and no code is transmitted to the DCU.

Certain keys are "auto-repeating" keys; that is, if held down for a certain period of time, they repeatedly transmit the corresponding keycode approximately 5 times per second. This capability is arbitrarily assignable on a per-key basis at assembly time. Initially only the "INC" and "DEC" keys are auto-repeating.

3.4.4.2.2 Display Encoding

There are basically three capabilities required of the RCDU display:

- arbitrary text as transmitted by the DCU;
- display formatting commands;
- "canned messages" contained in the RCDU memory that are displayed upon transmission of an abbreviation.

Except for the third requirement, these capabilities are found in common cathode-ray tube terminals. The RCDU therefore emulates a subset of the functions of a popular terminal, the Zenith Z-19. This permits the debugging of other PMS software using an RS-232 terminal. Moreover, this permits the RCDU to be used for other terminal applications that might prove useful.

> Printable characters are displayed at the current cursor location, and the cursor position is moved one position to the right. The printable characters include the graphic subset of ASCII (codes 20 (hex) through 7E (hex)) as well as the extended character set provided by the LCD display. These extensions include a left arrow, code 7F (hex); underlined alphabetic characters in the range 80 (hex) through 9F (hex); Japanese Kata-Kana characters in the code range A0 (hex) through DF (hex); and other underlined characters in the range E0 (hex) through FF (hex). Thus the RCDU printable character set spans the range from 20 (hex) through FF (hex).

> End-of-line wraparound is NOT implemented in the RCDU display algorithm. Thus, when the cursor reaches the rightmost column, subsequently received characters will overwrite whatever is in that position. An explicit cursor-positioning command (such as carriage return) would be required to move the cursor from that position.

> The following Z-19 display formatting commands are implemented:

>> - <Return> causes the cursor to move to the left margin of the current row.

>> - <line feed> causes the cursor to move down one row, remaining in the current column; if the cursor is in the bottom row, a scroll occurs, and the cursor position is not changed.

>> - <backspace> causes the cursor to move one position to the left; if the cursor is at the left margin, the command is ignored.

FSCM NO. 03652		
PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	
DATE	7/15/85	REV. G
SHEET NO.	67 of 73	

SRI International
Menlo Park, California 94025

- \<escape\> \<E\> erases the entire display
  and homes the cursor.

- \<escape\> \<H\> homes the cursor, leaving
  the text unchanged.

- \<escape\> \<K\> will erase (blank) the current
  row from the cursor position to the
  right margin, leaving the cursor position
  unchanged.

- \<escape\> \<Y\> \<row# + 31\> \<column# + 31\>
  positions the cursor to the absolute
  row and column given in the third and
  fourth bytes. If the row number or
  column number is out of range, no change
  occurs.

- \<escape\> \<x\> \<4\>
  Selects 5x7 blinking cursor font. (default)

- \<escape\> \<y\> \<4\>
  Selects underline cursor font.

- \<escape\> \<x\> \<5\>
  Disables cursor display.

- \<escape\> \<y\> \<5\>
  Enables cursor display. (default)

- \<escape\> \<1\> \<contrast + 31\>
  Sets the LCD display contrast to one of
  four settings (contrast = 0, 1, 2, 3).
  This command has no corresponding function
  in the Zenith Z-19 command set; the Z-19
  does not use the escape sequence lead-in
  "escape, 1".

- \<escape\> \<2\>
  Turns entire display OFF. This command,
  together with the following command,
  permits the entire display to be flashed on
  and off in a blinking manner; this capability
  can be used for attention-getting purposes.
  Note that this function is NOT the same as
  "escape, E", which clears the screen but
  does not remember the previous contents.
  This function has no corresponding version
  in the Zenith Z-19; the lead-in "escape, 2"
  is unused in the Z-19.

FSCM NO. 03652		
PROJ. NO.	5348	
SPEC. NO.	PMSF-20-0000-SP	
DATE	7/15/85	REV. G
SHEET NO.	68 of 73	

SRI International
Menlo Park, California 94025

- <escape> <3>

    Turns the entire display ON (default).
    See the description of the command above.

- <escape> <4>

    Selects a blinking cursor (default).
    This escape sequence is unused on the
    Z-19; the Z-19 cursor always blinks.

- <escape> <5>

    Selects a continuous (non-blinking)
    cursor. This escape sequence is unused
    on the Z-19 and there is no corresponding
    function.

An extensible set of "canned messages" is
provided. The escape sequence
<escape> <0> <index + 31> is used to select the canned
message. The lead-in "escape, 0" is unused by the Z-19.
The index selects a canned message from a table; each
entry in the canned message table includes the
literal text string and the row and column coordinates
of the leftmost character in the string.

3.4.5 Firmware

The firmware in the PMS consists of 4 PROM's, 2 in the Control Processor and 2 in the Data Processor. The first Control Processor PROM contains the data control routines, and the second PROM contains the experiment parameters. Only this second PROM need be changed when an experiment is changed or added. The two Data Processor PROM's contain code for acquiring heart rate and blood pressure data, controlling the blood pressure cuff, and computing blood pressure. The algorithms used in the blood pressure computation are proprietary to SRI International.

The source code for the PROM's was written to be assembled by the NSC800 assembler on the Tektronix 8560 Microprocessor Development System.

3.5 Qualification and Testing

Qualification and acceptance testing of the PMS was done according to the following plans and procedures:

PMSF-20-0000-TP, Qualification and Acceptance Test Plan for the Physiological Monitoring System

PMSF-20-0000-AP, Final Acceptance Test Procedure for the Physiological Monitoring System

PMSF-20-0000-CP, Certification Procedure for the Physiological Monitoring System

The Functional Test Procedure defined in PMSF-20-0000-AP should be performed before use whenever a PMS unit has not been used within the previous month. Portions of the Operational Verification Test Procedure defined in PMSF-20-0000-AP should be performed as necessary to diagnose problems or to verify operational performance.

3.6 Standard Sample

No standard samples are used.

4.0 Quality Assurance Provisions

See PMSF-20-0000-QP, Quality and Reliability Plan for the Physiological Monitoring System (PMS).

5.0 Preparation for Delivery

See End Item Specification.

SRI International
Menlo Park, California 94025

FSCM NO. 03652
PROJ. NO.   5348
SPEC. NO.   PMSF-20-0000-SP
DATE   7/15/85   REV. G
SHEET NO.   70 of 73

6.0 Notes

6.1 General Operations

The operation of each of the major components has been
basically described in each of the relevant sections. General
instructions for running an experiment are detailed in section
3.1.2.4, User Interface.

6.2 General Maintenance

Any maintenance that needs to be done on any of the major
components of the PMS has been mentioned in the relevant sections.
The only general maintenance that might be done by the user includes
refurbishing battery packs, changing fuses, and perhaps replacing
boards.

6.2.1 Refurbishing Battery Packs

This is discussed in section 3.4.3.2.

6.2.2 Changing Fuses

6.2.2.1 EUI Power Supply Fuses

The power supply to the EUI is fused on the motherboard by F1
(V- supply fuse) and F2 (V+ supply fuse). To replace these fuses, the
motherboard must be removed. The following steps describe the
process:

1. Remove the top half of the clamshell and unscrew the screw
visible in the battery compartment and the visible screws for the
removable chassis side. Reinstall the clamshell.

2. Remove the 14 screws for the bottom half of the clamshell
assembly and remove the assembly. Unscrew the screw located in the
middle of the analog board and the remaining removable chassis side
screws.

3. Remove the chassis side plate. It may be necessary to
move the top half of the clamshell away from the chassis. If so,
reinstall the clamshell upon completion.

4. Remove the analog and processor boards. Remove the screws
holding down the power supply board and set the board aside, being
careful to not lose any heat sink pieces.

5. Carefully disconnect all cables from the motherboard and
lay them out of the way.

6. Remove the 5 motherboard mounting screws and the
motherboard.

7. Remove and replace F1 and F2 and inspect for workmanship.
Have a Government QAR visually inspect.

8. Reassamble in the reverse order with the following additional steps:

   a. Ensure the screw insulator is installed in the center mounting hole of the motherboard.

   b. Ensure the heat sink insulators are properly installed on the power supply board.

9. Perform resistance checks between pins 35 and 34, and 33 and 34 on the EUI connector to verify that V- and V+, respectively, are now being supplied to the connector.

10. Perform the functional test procedure portion of the acceptance test procedure.

11. Perform the EUI load test (at 1/2 w) portion of the certification test. Do not power the system from a battery pack as required, rather adjust a dual power supply for approximately +/-8.5 v and power the PMS through the battery connector. This will ensure that the fuse is properly installed and that the system will operate satisfactorily.

6.2.2.2 External Power Supply Fuses

There are two fuses on the power supply board. The board does not need to be removed to replace these fuses. To access the board, follow the same procedure described in the preceding section for the mother board fuses up to the point of removing the power supply board screws. Instead of removing the screws, the following steps should be added:

   1. Measure the resistance of the fuse to verify that it is bad. If bad, the resistance will be infinite.

   2. Cut the old fuse out and remove the fuse leads from the terminal posts with a soldering iron. This step and the subsiquent steps should be performed by a qualified solderer.

   3. Solder in the new fuse.

   4. Clean and inspect the solder joint.

   5. Reassemble in reverse order.

6.2.3 Replacing Boards

A complete set of spare boards is supplied with the PMS units. The only boards that should be replaced by the user are the Processor Board (PMSF-DC-PR00) and the Analog Board (PMSF-DC-AN00). The other boards are relatively inaccessible and probably should be replaced by qualified personnel at SRI. However, the procedure for removing and replacing the motherboard was described in section 6.2.2 above. To remove and replace the power supply board, do the procedure through step 4, disconnecting the connector on the power supply board to remove it altogether, then replace the board by following the steps in the reverse order, as described further on in the procedure.

6.3 General Handling

6.3.1 Connectors

ORIGINAL PAGE IS
OF POOR QUALITY

The PMS should not be shipped or stored with any of the connectors mated. All connectors on the DCU should be capped when not in use. Connectors should not be mated or demated while power is applied to the DCU.

6.3.2 Battery Pack Handling and Usage

The battery packs always should be stored separately from the PMS. They should be stored in airtight containers.

An operating time log should be maintained for every battery pack. When the battery is in use, it is important to make sure that air can freely flow through the air holes on the connector end plate of the DCU.

6.3.3 Changing PROM's

From time to time it may be necessary to change one of more of the PROM's on the Processor Board of the DCU. Figure 6.3.3-1 shows the relative location of each of the four PROM's on the board. Each PROM should have a label on top of it identifying which PROM it is. DP1 and DP2 are the low and high order address Data Processor PROM's, respectively. CP1 and CP2 are the low and high order address Control Processor PROM's, respectively (CP2 is the Parameter PROM).
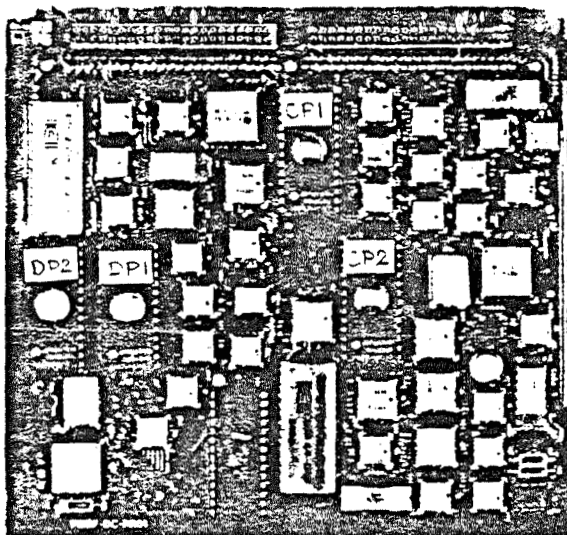

Figure 6.3.3-1 PROM Location on the Processor Board

To change a PROM, first make sure no power is applied to the PMS. Remove the card cover assembly by removing the screws that attach it to the chassis. At all times implement standard procedures for handling delicate CMOS circuitry.

Using a tool that will not damage the surface of the board under the PROM, carefully remove the old PROM. Check all the pins of the removed PROM to ascertain that no insert has come out of the socket and adhered to any pin. Insert the new PROM, making sure that pin 1 is in the correct orientation. Be very careful not to flex the board when pushing in the PROM.